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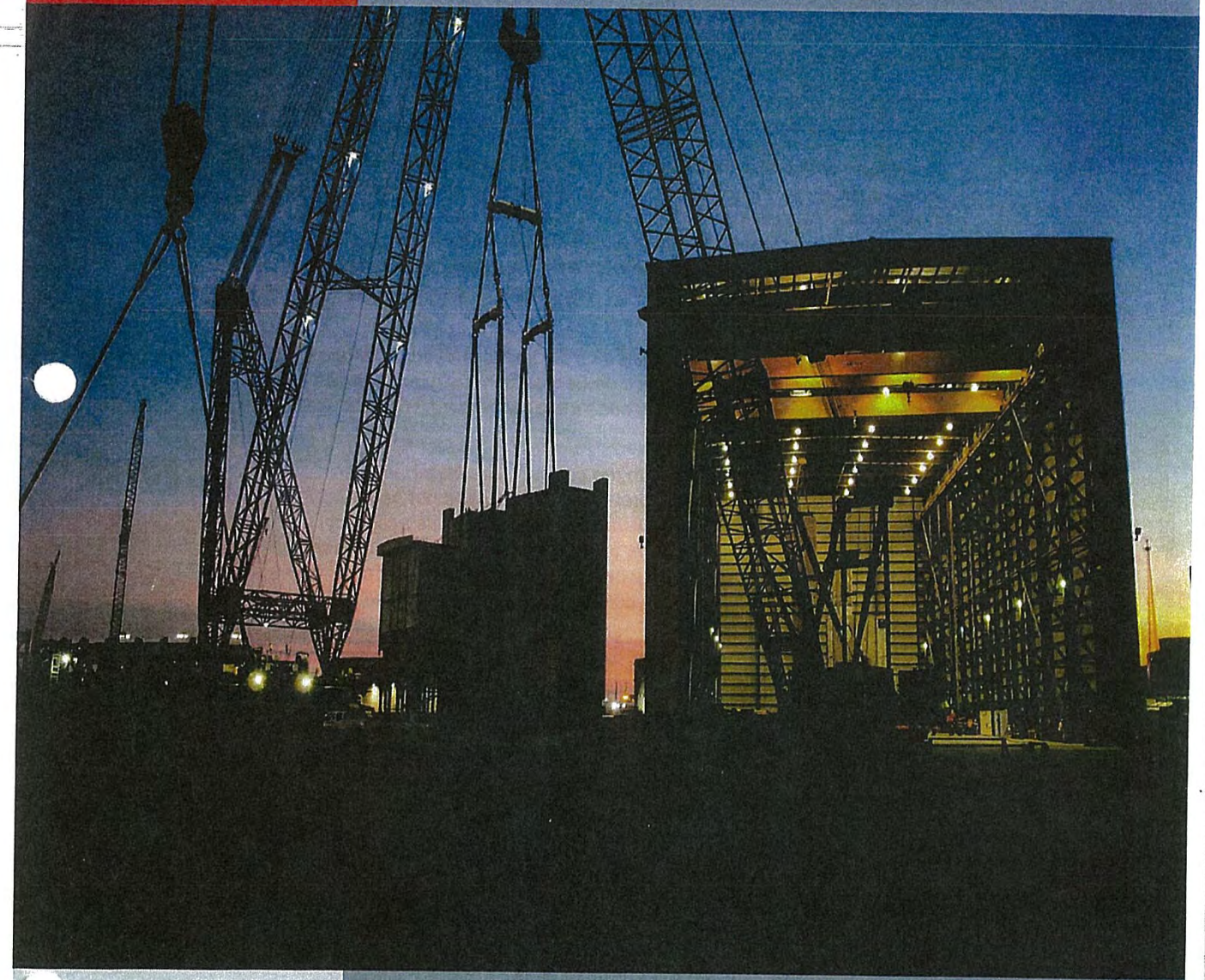
DRAFT

V.C. Summer
Nuclear Generating Station Units 2 & 3

Project Assessment Report

November 9, 2015



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34°17'55"N | 81°18'53"W

V.C. Summer Nuclear Generating Station Jenkinsville, SC USA

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Abbreviations and Acronyms

BIP	Boundary Identification Package
BPO	Blanket Purchase Order
CB&I	Chicago Bridge & Iron
CFPC	Certified for Procurement and Construction
CGD	Commercial Grade Dedication
COD	Commercial Operation Date
COLA	Combined License Application
CTG	Component Test Group
DAC	Design Acceptance Criteria
DCD	Design Control Document
DCP	Design Change Proposal
DD	Design Deliverables
E&DCR	Engineering & Design Coordination Report
EDC	Engineering Design Completion
eFIN	engineering Finish It Now
EPC	Engineering, Procurement, and Construction
FSAR	Final Safety Analysis Report
I&C	Instrumentation & Controls
IFC	Issued for Construction
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
ITP	Initial Test Program
JTWG	Joint Test Working Group
LAR	License Amendment Request
MAB	Module Assembly Building
N&D	Non-Conformance and Disposition Report
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
OCC	Operations Control Center
P&ID	Piping & Instrumentation Diagram
PMO	Project Management Organization
POD	Plan of the Day
PTG	Preoperational Test Group
RFID	Radio Frequency Identification
ROYG	Red-Orange-Yellow-Green
SCE&G	South Carolina Electric & Gas
SCH	Smith, Currie & Hancock LLP
SCPSA	South Carolina Public Service Authority
STG	Startup Test Group
UIN	Early Uncompleted ITAAC Notification
WBS	Work Breakdown Structure
WEC	Westinghouse Electric Company
WP	Work Package

Executive Summary

In accordance with a Professional Services Agreement signed on August 6, 2015 between Bechtel Power Corporation and Smith, Currie & Hancock LLP (SCH), Bechtel performed an assessment of the Virgil C. Summer Nuclear Generating Station (V.C. Summer) Units 2 & 3 project. The objective of the assessment was to assist SCH and the Owners (South Carolina Electric & Gas Company (SCE&G) and South Carolina Public Service Authority (SCPSA)) to better understand the current status and potential challenges of the project to help ensure the project is on the most cost efficient trajectory to completion.

Based on Bechtel's assessment, the current schedule is at risk. Significant issues affecting schedule include:

- The to-go scope quantities, installation rates, productivity, and staffing levels all point to project completion later than the current forecast. Bechtel's assessment, based on certain assumptions, is that the Unit 2 and Unit 3 commercial operation dates (CODs) will extend as follows:

Impacts on Commercial Operation Dates		
	Unit 2	Unit 3
Current COD	June 2019	June 2020
Adjustment	18 to 26 months	24 to 36 months
New COD	Dec 2020 to Aug 2021	June 2022 to June 2023

- While the Consortium's engineering, procurement, and construction (EPC) plans and schedules are integrated, the plans and schedules are not reflective of actual project circumstances.
- The Consortium lacks the project management integration needed for a successful project outcome.
- There is a lack of a shared vision, goals, and accountability between the Owners and the Consortium.
- The Contract does not appear to be serving the Owners or the Consortium particularly well.
- The detailed engineering design is not yet completed which will subsequently affect the performance of procurement and construction.
- The issued design is often not constructible resulting in a significant number of changes and causing delays.
- The oversight approach taken by the Owners does not allow for real-time, appropriate cost and schedule mitigation.

- The relationship between the Consortium partners (Westinghouse Electric Company (WEC) and Chicago Bridge & Iron (CB&I)) is strained, caused to a large extent by commercial issues.
- The recently announced acquisition of CB&I by WEC and the hiring of another construction contractor may help to resolve many of the Consortium-related commercial issues in the near term. However, this acquisition alone may not address the observed EPC shortcomings, therefore potentially causing further delays in mitigating the resulting project impacts. The issues at V.C. Summer rest with both engineering, procurement, and construction, but our observation is that the resolution of those issues are driven too often by commercial considerations rather than by overall EPC logic, often to the detriment of the Owners. There is concern that many of the drivers are still in place for this decision making dynamic to continue, thereby furthering the need for a much stronger EPC management organization within the Owners' team.

1. Introduction

1.1 Assessment Scope

In accordance with the August 6, 2015 Professional Services Agreement, Bechtel's team evaluated the current status and forecasted completion plan through the design, supply chain, and construction aspects of the project. The focus of the assessment was on understanding the issues that have caused impacts to date, assessing the effectiveness of the mitigation plans put into place to address those issues, and reviewing the project management tools and work processes being employed to plan and execute the project, including change management, through completion and turnover of the units.

The following process was used to perform the assessment:

- Data validation
- Site walkdowns
- Leadership team interviews
- Functional breakout sessions
- Preparation of report

Areas reviewed during the assessment included project management, engineering and licensing, procurement, construction, startup, and project controls. An assessment of the project schedule was also performed. During the assessment period, the Bechtel team:

- Reviewed 353 Consortium and Owner documents
- Attended 70 meetings with Consortium and Owner personnel
- Conducted 35 interviews of Consortium and Owner personnel
- Completed 24 site walkdowns/real-time observations
- Attended 7 subject-specific presentations

1.2 Documents Reviewed

The assessment is based on the data, schedule, and other information provided to the team by the Consortium and the Owners during August, September, and October 2015. A listing of documents received and reviewed during the assessment is provided in Appendix A. Some data and information was provided electronically by the Owners and the Consortium. For the majority of data and information, a single hard copy was placed in a reading room at the site and no additional copies could be made. This limited the ability of the Bechtel team to fully assess the information (e.g., engineering schedules, ROYG (red-orange-yellow-green) report, etc.). Further, many documents that contained sensitive information (e.g., contract terms, financial details, etc.) were redacted.

Materials received, collected, or prepared by Bechtel in connection with the assessment are the property of the Owners and were treated as confidential by Bechtel.

1.3 Assessment Team

The assessment was performed by the following Bechtel professionals:

Dick Miller	Manager of Operations, Assessment Project Lead
Carl Rau	Executive Sponsor
George Spindle	Construction Manager
Mike Robinson	Construction Manager
Ed Sherow	Engineering Manager
Ron Beck	Project Manager (Engineering and Construction)
Steve Routh	Project Manager (Engineering and Licensing)
Bob Exton	Procurement Manager
Jason Moore	Project Controls Manager
Jonathon Burstein	Project Controls Manager
Bob Pedigo	Startup Manager
Jerry Pettis	Project Administrator
Reviewers	
Ty Troutman	Principal Vice President, Assessment Reviewer
John Atwell	Principal Vice President, Assessment Reviewer

The collective experience of these senior managers includes:

- Over 500 years of total experience
- Over 300 years of EPC nuclear experience
- Project management experience on over 85 EPC projects

Resumes of the Bechtel assessment team personnel are included in Appendix B.

1.4 Assessment Timeline

Key dates included:

July 1, 2015	Initial data request issued by Bechtel
August 6, 2015	Agreement signed
August 13, 2015	Kickoff meeting with the Owners and the Consortium
August 14, 2015	Initial documents received from the Consortium

August 19, 2015	Portions of Integrated Project Schedule received from the Consortium
September 8, 2015	Bechtel team mobilized to site
September 9, 2015	Consortium presentation to Bechtel team
September 8, 2015 to October 16, 2015	Bechtel team at site performing walkdowns, interviews, document reviews, etc.
October 22, 2015	Bechtel presentation to SCH, SCE&G, and Santee Cooper
November 6, 2015	Bechtel report issued to SCH

Copies of Bechtel's weekly reports to SCE&G and Santee Cooper are provided in Appendix C.

2. Project Management

This section describes the assessment of the project management aspects of the project. Section 2.1 provides a summary of the assessment. Section 2.2 provides project management observations and recommendations.

2.1 Summary

The execution of any large scale EPC project is a cross-functional task covering the entire range of these services plus more as covered in the contractual agreement(s). To ensure that that the range of services is fully integrated such that the project can be executed as efficiently as practical, it is incumbent upon the project management staff to plan, organize, direct, and control all facets of the project. As the Owners, SCE&G and Santee Cooper have the responsibilities to manage their portion of the prime contract and ensure that the Consortium contractors are fulfilling their contractual obligations.

In performing the project management assessment, Bechtel approached this project management function in two ways. Bechtel assessed how the Owners were managing their contractual responsibilities and secondly how the Consortium partners were managing their contractual obligations. Contractual documents were provided to Bechtel for the assessment; however, the contractual documents were redacted to a large extent. Bechtel was not provided any commercial terms associated with the prime contract agreement between the Owners and the Consortium. As a consequence and as regards any commercial terms between the Owner and the Consortium or between the Consortium partners, Bechtel was left to rely on information provided during management interviews, presentations, and attendance at daily, weekly, and monthly meetings.

2.2 Observations and Recommendations

Project management observations and recommendations are identified in Table 2-1.

Table 2-1. Project Management Observations and Recommendations

No.	Description
PM1	Observation(s) • The Consortium's project management approach does not provide appropriate visibility nor does it provide accuracy on project progress and performance. • There is a lack of accountability in various Owner and Consortium departments. • The Consortium's lack of project management integration (e.g., resolution of EPC issues) is a significant reason for the current construction installation challenges and project schedule delays. • The approach taken by the Owners does not allow for real-time, appropriate cost and schedule mitigation.

Table 2-1. Project Management Observations and Recommendations	
No.	**Description**
	Recommendation(s) • Develop an Owners' Project Management Organization (PMO) and staff with EPC-experienced personnel dedicated to the project that are empowered with the roles, responsibilities, and accountabilities for making the needed project-related decisions to keep the project on track. • Assign recognized high-performing personnel to the current management personnel in WEC and CB&I (i.e., shadow positions) as part of a major improvement plan.
PM2	Observation(s) The WEC-CB&I relationship is strained, caused to a large extent by commercial issues (see last bullet of Executive Summary). Recommendation(s) • The Owners should take an active role in determining the reason(s) for the relationship and develop an action plan, including possible new contract terms, to fix the relationship.
PM3	Observation(s) The overall morale on the project is low. Recommendation(s) • The Project needs to experience some successes, no matter how small. Publish and post scheduled activities for the coming months around the job site. Post activities that have a high likelihood of being completed within schedule. Reward those responsible for achieving success (i.e., make success contagious). • Recognize individuals for their contributions to the project. For example, have an employee of the month from the various functions/various craft trades and publicly reward them. Rewards could include preferred parking for a month, gift certificates, etc.
PM4	Observation(s) • It appears that the Contract has created an imbalance between the Owners and the Consortium. The Consortium does not appear to be commercially motivated to meet Owner goals. • Engineering has not been completely responsive to Procurement and Construction requests for clarification and changes (e.g., timeliness, constructible designs); this is believed to be caused mostly by the commercial situation. • The Consortium's commercial structure, while not shared, is outwardly affecting the day-to-day working relationships between the Consortium partners and is creating performance issues, including significant non-manual turnover. Recommendation(s) • Align commercial conditions with the project goals. • Facilitate Owner and Consortium teambuilding. If necessary, replace personnel with others that share the goals developed by the project. • Determine the realistic to-go forecast costs for the project completion, make adjustments/changes where necessary.

3. Engineering and Licensing

This section describes the assessment of the engineering and licensing aspects of the project. Section 3.1 provides a summary of the engineering status. Section 3.2 addresses current licensing status. Section 3.3 provides engineering and licensing observations and recommendations.

3.1 Engineering Current Status

There are approximately 15 to 18 months of sustained detailed design engineering to be completed by the Consortium for the AP1000 standard plant and the V.C. Summer site specific design. The majority of this engineering is scheduled to be completed by December 2016 based on the information contained in the WEC and CB&I to-go engineering completion schedules. Some of this design work is near term critical path to support procurement and construction (primarily civil and module work), while the balance is design work which must be completed to support fuel load.

Other significant engineering workloads include completing design engineering work needed for fuel load and startup, resolution of Engineering & Design Coordination Reports (E&DCRs), resolution of Non-Conformance and Disposition Reports (N&Ds), and vendor document reviews.

3.1.1 WEC Engineering

In general, WEC is responsible for performing detailed design engineering for the nuclear island (containment and auxiliary building) structures; the plant safety systems; ASME Class 1, 2 and 3 piping systems; and nuclear island structural, equipment, and piping modules. Turbine instrumentation and controls (I&C) are being designed by Toshiba for WEC. WEC also specifies and procures all standard plant valves.

WEC states that they completed their detailed design engineering for the U.S. AP1000 standard plant (V.C. Summer and Vogtle) in April 2015. Engineering complete is defined as Certified for Procurement and Construction (CFPC) or Issued for Construction (IFC). WEC has identified that approximately 4% of the design engineering has not yet been completed. This remaining engineering is referred to as "Engineering Debt" and it includes both the engineering that must be completed to support procurement and plant construction as well as the substantial other engineering activities needed for fuel load and startup. I&C design is also not completed and is not included in the to-go "debt" work scope. Design Deliverables (DDs) consist of construction and procurement drawings, documentation, and other "debt" reconciliation. Approximately 1,400 DDs remain to be completed. During the September 9, 2015 Consortium presentation, WEC stated that they were 94.3% design complete.

WEC's major to-go design priorities to support construction are:

- Electrical tray, conduit, and supports design above El. 100' in the auxiliary building.

- Civil design above El. 100' in the auxiliary building; C7 reinforcing steel El. 135' – El. 162' in the auxiliary building.
- A5/A6 floors in the auxiliary building.
- SPL18 and SPL51 floor modules design modifications based on China installation experience; this is about 20% review complete and the modified design is urgently needed by construction to support module fabrication and installation.

WEC detailed design engineering is being performed at its home office in Cranberry, PA, offices in Spain, and to a limited extent at the V.C. Summer and Vogtle sites and in other WEC offices. WEC has approximately 520 engineering personnel assigned to the AP1000 design engineering efforts, but only about 40 are located at the V.C. Summer site. Within the Cranberry engineering staff, WEC has established three "response teams" consisting of approximately 80 engineers dedicated to addressing emergent issues requiring engineering disposition or resolution. These teams are civil-electrical, modules, and mechanical. WEC is also planning to put in place a review board for electrical and piping to anticipate potential design changes and construction challenges and resolve these well in advance of the construction need date.

3.1.2 CB&I Engineering

In general, CB&I is responsible for performing detailed design engineering for the balance of plant including the turbine island, annex building, radwaste building, diesel generator building, service building, administration building, and site specific structures and systems. CB&I is also responsible for the design of approximately 45 systems, including ASME B31.1 piping systems and all cable routing and scheduling. CB&I is the design authority for the AP1000 standard plant balance of plant and site specific design work.

CB&I has not yet declared "Engineering Complete." The integrated project schedules showed August 31, 2015 as the "Engineering Complete" date. During the September 9, 2015 Consortium presentation, CB&I stated that they were 82.5% design complete.

CB&I's to-go standard plant ("1 x 4") and V.C. Summer site specific work is contained in its P6 to-go engineering schedule. A review of this schedule shows it to be comprehensive and it identifies interfaces with procurement, vendors, construction, and WEC engineering. CB&I's major to-go design priorities to support construction are:

- Chilled water system redesign, scheduled to be issued by December 2015
- Turbine drain and vent system redesign, scheduled to be issued by December 2015
- Annex building reinforcing steel design, being resolved by CB&I's Vogtle design team, common for V.C. Summer
- Main steam piping overdesign (main steam pipe wall thickness over-specified by WEC) – creating revised support designs and problems with the design of the main steam pipe anchor at the auxiliary building wall (stargate)

- ASME N-5 data reports, which are planned to be inserted into the construction schedule by the end of September 2015.

CB&I's detailed design engineering is being performed primarily onsite at V.C. Summer with support from the Vogtle site and CB&I's home office locations. CB&I has approximately 270 engineering personnel assigned to the AP1000 and site specific scope, of which 184 are located at V.C. Summer, 27 at Vogtle, and the remaining personnel in CB&I's Charlotte, NC, or Canton, MA, offices.

3.1.3 SCE&G Engineering

SCE&G provides engineering oversight of WEC and CB&I. This oversight includes the following generic items:

- Monthly schedule review and progress meetings
- E&DCR review (on a sampling basis)
- Review of major equipment N&Ds for "accept as is" or "repair"
- Review and input to departure evaluations and license amendment requests (LARs)
- ITAAC coordination and closure
- Review and approval of "upper tier" design documents, such as P&IDs and single lines.

As part of its efforts, SCE&G maintains close coordination with its Southern Company counterparts for Vogtle Units 3 & 4.

SCE&G engineering consists of 17 persons--the manager, 2 supervisors, and 14 engineers.

3.1.4 Control of Engineering Activities

WEC and CB&I hold a weekly engineering schedule update and interface meeting to status engineering progress. The ROYG report is reviewed and it identifies engineering activities that are impacting construction. A gap file report is also prepared to identify engineering and construction activity interface ties. SCE&G also holds monthly engineering completion status meetings with WEC and CB&I.

The design change control process being used by both WEC and CB&I consists of design change proposals (DCPs) and E&DCRs. Both are managed through a "stage gate" process. DCPs are noted as "Class 1" and "Class 2" as are E&DCRs. Class 3 E&DCRs are not part of the stage gate process for design change control.

Both WEC and CB&I employ an engineering Finish It Now (eFIN) process in support of Construction. Emergent work is taking priority to DD completion within both the WEC and CB&I design organizations. WEC indicated that it expects changes (rework) to a few ASME pipe spools that have already been delivered to the site. Most of the changes (rework) are expected in ASME

pipe supports resulting from changes in pipe support locations. Discussions with CB&I electrical field engineers and superintendents indicate that there may be similar rework issues with WEC electrical cable tray support designs due to design complexity.

3.1.5 Post-Detailed Design Engineering Closure Plan

Beyond completing the detailed design needed for construction, there remains a significant amount of engineering that must be performed to support fuel load and startup. This primarily involves the design engineering work performed by WEC, and to a lesser degree the work performed by CB&I. These activities and programs must be completed to support preoperational testing, startup, and system turnover for fuel load and power ascension testing and include:

- Final nuclear steam supply system (NSSS) safety analyses for as-built conditions, including small break and large break loss-of-coolant accident analyses
- ASME pipe stress and pipe support as-built reconciliation
- Structural adequacy evaluation for Category I structures
- Containment structural integrity and containment integrated leak rate test programs (including engineering acceptance criteria)
- Hot functional and vibration monitoring test program (including engineering acceptance criteria)
- Class 1 stress reports (components and piping)
- Engineering support to component testing and pre-operational testing and startup
- Engineering document/record turnover to the Owner

This work needs to be fully scoped, resource-loaded, and scheduled in the P6 integrated project schedule with appropriate ties to construction and startup program activities. Based on a review of the current schedule, the Consortium has not started this planning effort.

3.1.6 Design Change Control and Emergent Design Engineering Work Scope

Because of design complexity, particularly reinforcing bar design and spacing tolerance requirements, structural module fabrication in offsite and onsite fabrication shops is requiring a significant amount of E&DCRs to be reviewed and dispositioned by engineering to modify issued designs to be more constructible. This trend will continue as construction moves to the installation of piping, cable tray, conduit, HVAC, and equipment/components, especially with the supports for these items owing to the complexity of design that has been identified in advance by construction personnel.

The number of issues identified during the current civil phase of the construction effort is significant. These issues have been identified during the erection of the nuclear island and turbine island structures which comprise reinforced concrete basemats, exterior and interior walls, as well as the auxiliary building and several major steel composite structural modules in the containment.

Current data shows that from May to September 2015 there is a trend of more E&DCRs being initiated (requests made) than are being closed (approved/dispositioned). This data shows that current E&DCR backlog work is not being worked off and indicates that a continued focus and possible increase in staffing is required:

Responsible Company	Average Initiated	Average Closed	Open at End of September 2015
WEC	~85	~71	~78
CB&I	161	149	60

The incorporation of E&DCRs into the parent document is tracked and status data is provided in typical engineering design completion (EDC) dashboards (as seen in the Tuesday site POD meeting data). The data in the September 15, 2015 POD showed E&DCR incorporation is behind (shown with status "red" for 3 of 4 categories).

E&DCR response support has the potential to pull resources from other ongoing design completion efforts and negatively impact emergent construction needs if timely responses are not provided. The incorporation of approved E&DCRs into the parent document will be a resource demand, but failing to timely incorporate E&DCRs into parent documents will violate procedures and provide a potential error trap of multiple changes against work being planned and implemented.

3.1.7 Non-Conformance and Disposition Reports

N&Ds require design engineering support for disposition approvals and assessment of impacts to issued design for dispositions of "repair" and "use as is". This disposition concurrence is an emergent activity that is usually a high priority to support construction.

N&Ds are tracked and summaries are provided in various reports. The Thursday POD report has both WEC and CB&I open N&D reports by age. The September 24, 2015 POD showed 183 N&Ds open for WEC action and 477 N&Ds open for CB&I action. The October 1, 2015 POD showed 183 N&Ds for WEC action and 328 N&Ds open for CB&I action. (Note: The CB&I action includes both design and field engineering actions as the data split between groups was not readily available.)

N&D response support has the potential to pull resources from other ongoing design completion efforts to support the emergent construction needs.

3.1.8 Vendor Document Review and Approval

It was identified that WEC has approximately 35,000 remaining vendor documents to review and approve and that CB&I has approximately 100,000 vendor documents yet to approve. Procurement engineering has the responsibility for reviewing and approving these documents.

3.1.9 Technical Engineering Issues

Two significant issues that the Consortium engineering groups are working on include tube steel wall thickness and equipment preservation:

- **Tube Steel Wall Thickness (Hollow Structural Shapes).** The site has identified that there is an industry-wide issue with the fabrication of cold-formed welded and seamless tube steel structural shapes. The manufacturing process for A500 structural tube shapes creates wall thicknesses less than that required by the ASTM material specification. WEC and CB&I are working together to address a plan that will allow the use of this material at both Vogtle and V.C. Summer.
- **Equipment Preservation.** Early site delivery of equipment and components, coupled with ongoing construction schedule delays, is creating several problems. The original equipment specifications specified preventative maintenance or on-site storage requirements typical for "normal" time between site delivery and installation in the plant. Engineering is now updating equipment specifications so that purchasing/procurement can contact suppliers to request them to provide updated preventative maintenance or storage requirements necessary for a longer storage period between site delivery and plant installation/equipment operation. It is unknown whether any equipment has degraded to the point where it must be replaced, and it is unknown whether equipment and component warranties are impacted.

Further, the Consortium has compiled a listing of major risks to project completion extracted from the project risk register. From an engineering perspective, the major risks include:

- Reactor coolant pump issues
- Coupler weld issues
- Passive core cooling system issues
- Auxiliary building wall 11 changes
- Reactor coolant system/steam generator system transient analysis
- Generic Safety Issue 191 cable debris issue
- Motor and air operated valve operational setup sheets

The Consortium should endeavor to address and resolve these risks to minimize project impacts.

3.2 Licensing Current Status

The V.C. Summer licensing effort appears to be well organized and staffed by personnel with extensive experience with the AP1000 Design Control Document (DCD), the V.C. Summer (and Vogtle) Combined License Applications (COLAs), and interactions with the NRC.

3.2.1 Licensing Staffing

SCE&G manages the overall licensing program for V.C. Summer and they work closely with the licensing and engineering personnel from Southern Company for the Vogtle project. WEC manages the Consortium's licensing efforts.

There are 14 personnel in the SCE&G licensing group. 5 persons handle LARs and departures. The rest of the group handles NRC inspections, other permits, Final Safety Analysis Report (FSAR) update, the 10 CFR 52 change process, and operating programs.

The WEC licensing organization currently has 9 personnel at the site. Four of these personnel are working on licensing issues and 5 are dedicated to the closure of Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). The number of ITAAC personnel is expected to increase to 10.

In the Cranberry offices, WEC has one director, 3 supervisors, and 22 engineers working on LARs, departures, and regulatory issues.

CB&I has 2 licensing personnel assigned at the site and 1 manager in Charlotte.

3.2.2 License Amendment Requests and Departures

Currently there are 120 LARs and 657 departures. The breakdown of LARs is as follows:

35	WEC LARs approved by the NRC
2	SCE&G LARs approved by the NRC
18	LARs submitted to the NRC, but not yet approved
63	Not yet submitted to the NRC
2	Vogtle only
120	Total

Known LARs appear to be well in hand with detailed schedules developed for each LAR. There are active and continuous interactions with the NRC on each LAR and the NRC is working to meet construction need dates. The schedules for LAR 30 and 111 were reviewed and they include a good breakdown of schedule activities and durations for these LARs.

The Consortium is tracking their schedule and quality metrics for licensing change packages and improvements have been seen in both areas.

SCE&G Licensing is working to improve the turnaround time for incorporating LARs and departures into the integrated FSAR. At the time of the assessment, 1 approved LAR and 108 approved departures had not been incorporated. Formal revisions to the FSAR are issued every 6 months.

Various LARs have represented significant project challenges since the start of safety-related construction including:

LARs 54, 55	Basemat ACI-349 shear reinforcement (February 2013)
LAR 60	Auxiliary building structural floors (July 2014)
LAR 72	CA01 module anchor and CA05 (March 2015)
LAR 78	CA04 tolerance change (August 2015)
LARs 110, 111	AWS D1.1-2000 (September 2015 and TBD)
LAR 30	Remove MSIV compartment vents and change penetration rebar design/turbine bay wall 11.2 tornado missiles (TBD)

The Consortium identifies the possibility of emergent LARs as one of the project's significant risks. These are LARs (like the recent LAR on CA22 rebar) that are discovered late and have the potential for impacting construction work progress. The various tight tolerances identified in DCD Tier 1, Table 3.3-1, "Definition of Wall Thicknesses for Nuclear Island Buildings, Turbine Building, and Annex Building" are a continuing concern with the civil construction work underway. And, as the number of construction work fronts expands, the potential for identifying emergent LARs (and departures) may increase.

3.2.3 ITAAC

There are 873 ITAAC. Thirteen (13) of the ITAAC have been closed (about 1.5%).

An ITAAC schedule has been developed that includes the closure activities for each ITAAC. The schedule is a good tool to track the efforts for ITAAC closure. Periodic ITAAC schedule reports are also submitted to the NRC.

All ITAACs must be closed by fuel load. This will be a significant challenge requiring substantial efforts by the engineering and licensing organizations in the late stages of the construction effort. The current schedule shows a peak of almost 120 ITAAC closures in January 2018 and over 90 in June 2018.

ITAAC performance and documentation plans have been prepared for each ITAAC. Several examples were reviewed during the assessment:

- APP-RNS-ITH-004, Standard Plant ITAAC 2.3 06.09b.iv
- APP-PCS-ITH-014, Standard Plant ITAAC 2.2 02.02a
- APP-RCS-ITH-048, Standard Plant ITAAC 2.1 02.11b.iii
- APP-RCS-ITH-056, Standard Plant ITAAC 2.1 02.08b
- APP-RCS-ITH-060, Standard Plant ITAAC 2.1 02.08d.vii

These plans appear to be complete and identify the responsible organizations, ITAAC wording, supporting documents, and the ITAAC performance and documentation plan. The plans include the logic for ITAAC performance, deliverables to support ITAAC submittal, personnel identification/ assignment, materials or instrumentation procurement needed, vendor support needed, and the schedule for performance (including schedule activities in the integrated project schedule). A draft of the ITAAC closure letter is also included in the plan.

SCE&G and Southern Company have recently met with the NRC to discuss the concept of Early Uncompleted ITAAC Notification (UIN). The UIN concept of getting early NRC agreement on planned actions for later verification when completed could help with the high number of ITAAC closures at the end of the construction effort.

Public involvement or intervention in the ITAAC closure process is considered a project risk, although the potential for intervention is viewed as limited based on the specific 10 CFR 52.103 criteria.

The Consortium has identified delivered equipment conformance to ITAAC requirements as one of the project's significant risks.

3.3 Observations and Recommendations

Engineering observations and recommendations are identified in Table 3-1.

Table 3-1. Engineering Observations and Recommendations

No.	Description
E1	Observation(s) • Numerous E&DCRs are being created, processed, and implemented due to incomplete design or to resolve constructability issues. • Based on the team's observations of current civil work, the issued design is often not constructible (currently averaging over 600 changes per month). The complexity of the engineering design has resulted in a significant number of changes to make the design constructible. • The forecast and scheduled/work-off plan is unclear with respect to E&DCRs. Recommendation(s) • Initiate a focused effort to complete known design "debt" to assist construction planning and to eliminate one source of E&DCRs. • Establish a forecast based on historical data and staff on a level of effort basis to support. Provide additional staffing to address emergent E&DCRs and work off the current backlog. Adjust the make-up of the team expertise (civil, piping, electrical, etc.) to support the different stages of construction. • Locate dedicated WEC engineering response teams to the site with design authority to resolve E&DCR issues. • Establish a WEC/CB&I "light structures" design organization at the site to work with construction to redesign and reissue piping, HVAC, conduit, and tray supports that have been identified as difficult or impossible to construct (in advance of the construction need date), and to support

Table 3-1. Engineering Observations and Recommendations	
No.	**Description**
	the design of field run commodities such and conduit and instrumentation tubing that have yet to be installed.
E2	Observation(s) • The work package data prepared by field engineering is checked for content accuracy and completeness in accordance with CB&I procedures NCSP 2-19, NCSP 2-12, NCSP 2-7, and CSI 2-19. All of the required information is then placed into a binder(s) and sent to document control, who then manages the daily sign out, sign in of the work package by the craft. In some instances, the work package is in three binders – instructions, engineering drawings, and E&DCRs (change paper not yet incorporated into the parent drawings). • Simplification of the entire work package is desired, and it was identified that a task force was being assembled to figure out how to make the process simpler and streamline the work package physical size. • Approximately 2,000 work packages have been written to date; 800 of these are closed; 1,200 in some state of being worked, 100-200 are checked out from document control daily, and 18,500 to 24,000 total are expected to be written for Units 2 and 3. Recommendation(s) • Use a Six Sigma approach to simplify the size and content of the work package. • Strictly enforce within WEC and CB&I design engineering that no more than four change papers against a design drawing may exist before they must be incorporated into the parent document for re-issue to construction.
E3	Observation(s) During an October 13, 2015 visit to the Unit 2 containment document control drawing annex, more than several drawings were identified as being annotated with 10 or more changes. Document control personnel had previously indicated that per plant requirements, drawings should be revised after four (4) changes. In an unscientific sampling of ten (10) drawings, four (4) were found to exceed four (4) changes with one containing 33 active changes. The potential impacts of excessive changes to existing drawing revisions include the additional time burden on field personnel performing work using the drawings and document control personnel maintaining the drawings. Additionally, it complicates the ability of field workers to verify that work is being performed to the latest approved drawing. Recommendation(s) • Review current processes and resources to determine why plant drawing revision requirements are not being met. Based on the results, revise process and/or add resources to ensure that engineering drawings are revised in a timely manner.
E4	Observation(s) • Numerous late (just prior to or during installation) N&Ds to document installation issues are being created, processed, and implemented to support supplier or constructability issues. • The forecast and scheduled/work-off plan was unclear to the assessment team with respect to N&Ds. • There appears to be inadequate coordination between construction, field engineering, and design engineering on preliminary and final disposition N&Ds.

Table 3-1. Engineering Observations and Recommendations	
No.	**Description**
	Recommendation(s) • Initiate a focused effort on planning and review of design, vendor/contractor documents and tolerances to eliminate or have early identification of N&Ds. • Establish a forecast based on historical data and staff on a level of effort basis to support. Adjust the make-up of the team expertise (civil, piping, electrical, etc.) to support the different stages of construction. • Create/revise the process to enhance coordination between construction, field engineering, and design engineering for N&Ds.
E5	Observation(s) • The Strategic Planning Group reviews electrical, piping, and I&C for everything but yard work. The deliverables from this group includes a "room plan" and the goal is to perform this review approximately 6-9 months in advance of when the work is scheduled; to identify all the things that must be installed in a room prior to the room ceiling being installed. The group has a staff of 14. • Review priority is set by construction. Approximately 3,000 work packages have been scoped (electrical and piping only) and approximately 100 have been planned electronically (several more were recently reviewed with the assessment team). Not much electrical design has been completed and issued for construction to be available and that which is issued is considered problematic in many cases. • Pipe supports seem overly complicated; in containment electrical supports are "box beams"; room plan being developed to support the boundary information package (BIP) to support system turnover. Recommendation(s) • The standard plant 3D model should be updated so that it accurately reflects the final design so that it will better support understanding what is in a room that must be constructed. • If possible, the 3D model should be put under configuration control so that images and data drawn from it can be relied on. • E&DCRs and N&Ds should be rolled into design drawings and the 3D model to reduce the potential for human error in missing a requirement shown on these change documents.
E6	Observation(s) • Several significant problem areas are being actively worked to resolution: — Chilled water system. Redesign is in progress and will be resolved by December 2015. — Turbine drain and vent system. Redesign is in progress and will be resolved by December 2015. — Annex building reinforcing steel. This issue is being resolved at Vogtle. — Main steam piping (WEC inside auxiliary building; CB&I outside auxiliary building). WEC over-specified the main steam pipe wall thickness. This resulted in a new stress analysis that shows supports overloaded and being redesigned (thicker pipe equals more weight than originally analyzed); created a major problem with the main steam pipe anchor at the auxiliary building wall (stargate). • Equipment preservation is requiring engineering to revise specifications and go back to vendors to obtain new vendor submittals for equipment preservation requirements not originally

Table 3-1. Engineering Observations and Recommendations	
No.	**Description**
	anticipated to be required (because equipment is being delivered to the site well in advance of the construction need dates and construction need dates have slipped (compounding the problem). Recommendation(s) • Assess the practicality of buying new main steam pipe with the correct wall thickness rather than performing counter boring operations in the field and redesign of the stargate anchor, which may require changes to a 'special processes' specification or manual. • Evaluate if equipment site delivery can be delayed to minimize field equipment protection problems prior to installation in the plant.
E7	Observation(s) • An E&DCR is required for all changes, including software (e.g., calculation revision). • WEC performed an E&DCR study for the period May 15 – August 15, 2015. E&DCRs were classified as home office issues (unsolicited change), construction impact, and exceptions. A new study covering August 15 – December 15, 2015 is in progress. • Work package planning (6 months in advance of construction) can identify issues requiring resolution. WEC is part of the new site Strategic Planning Group. • The construction planning and constructability review efforts are not far enough out in front of the construction effort to minimize impacts. Recommendation(s) • Intensify the efforts of the Strategic Planning Group, work package planning, constructability reviews, etc. to identify design changes needed well in advance of the construction need date. • Look-ahead beyond where construction is today and work with the site Strategic Planning Group to roll in E&DCRs for all design documents associated with the room being planned, so that the room plan deliverable has the most up to date design documents.
E8	Observation(s) • The two major design areas yet to be issued are electrical and civil: — Electrical – above El. 100' in the auxiliary building (trays and conduit). — Civil – above El, 100' in the auxiliary building – C7 reinforcing steel release; CA50 modules; A5 (El. 135') and A6 (El. 117') floors (embeds for as-procured commodities); floor modules SPL18 and SPL51 – China experience – reviewing first 20% of changes and categorizing as "must have"; a simplification design package for "must haves" to be issued by WEC (in schedule). Recommendation(s) • Place emphasis on getting these new designs completed and associated drawings issued as soon as possible to construction/procurement. • Conduct a constructability review meeting with construction prior to issue in order to avoid the need for changes.
E9	Observation(s) • The resolution of open items and emergent site issues is shared with Vogtle for standard plant (1 x 4) designs. • WEC has three (3) dedicated response teams in Cranberry to address emergent issues –

Table 3-1. Engineering Observations and Recommendations	
No.	**Description**
	civil-electrical, modules, mechanical. Includes about 80 engineers (doubled in size since the April 30, 2015 design complete declaration). • Post-Engineering Design Closure Plan – includes items such as hot functional testing plan, startup support, piping and supports as-built reconciliation, document turnover program, etc. WEC is identifying and verify this emergent work now. These activities will be added to the schedule, resource loaded, and tied to construction/startup/fuel load. • Domestic hold removal is tracked and statused weekly. These are tied to construction need dates and consist of holds on design drawings that must be released so that construction can proceed with the work identified within the hold. These are reviewed weekly with project controls and statused weekly on a dashboard. • The EDC dashboard shows an increase in "Approved DCPs/Doc Pairs" requiring closure over the past several weeks with most coming from civil, which is indicative of the current major construction work front. • A weekly four hour meeting is held with engineering to review/status the to-go schedule and the above items. Recommendation(s) • WEC engineering should continue to stay on top of emergent issues including maintaining focus on the increase in Approved DCPs/Doc Pairs requiring closure. • Add appropriate staff to work off the backlog of approximately 1,150 of 1,400 items identified on the September 14, 2015 dashboard. • Complete the identification and resource loading of the post-engineering design closure plan and load activities/resources into the P6 schedule. Assess changes to staffing that may be required to support this work. • The weekly four hour engineering schedule meeting is a good practice and should continue.
E10	Observation(s) • The Strategic Planning Group was recently formed to review and prepare a room plan which, at a high level, identifies all the construction work required to be completed in a given plant room, and a general sequence of installation of the commodities within the room. The room plan review is planned to be performed approximately 6 to 9 months in advance of the construction start date for the room/area. • Operating procedures for the Strategic Planning Group have been approved. The current staff is 14. • The effort identifies only electrical, piping, I&C, and modules work for a given room. No material quantity takeoffs or yard work planning is included. Field engineering does all other construction planning. • The priority of room plan development is set by construction. • The room plan process came into existence because of the difficulty of pulling together all of the design drawings for all commodities required to be installed in a room, coupled with trying to comply with issued/approved but not incorporated change paper (E&DCRs). • The room plan deliverable is input to work package planning that is performed by the central planning group which is newly formed and has a staff of 28. • Approximately 3,000 work packages (electrical, mechanical) have been scoped. Approximately 100 rooms planned to date (electronically).

Table 3-1. Engineering Observations and Recommendations	
No.	**Description**
	• Work packages are being made smaller and reasonably scoped through interactions with CB&I construction; prepared by commodity (e.g., piping, pipe support, electrical, etc.). • Preliminary findings in the room plans are that piping and electrical tray supports are complicated and congested and will be a significant challenge to install. This could result in a significant amount of emergent E&DCRs and N&Ds similar to the civil design problems. • Work packages are being scoped to be consistent with the startup boundary information plans so that they support system turnover to the pre-op test group. • The 3D model is used but it is not up to date; commodity clashes (intersections) are seen and noted. • Piping and electrical support locations cannot be easily tied to civil drawing baseplates. This requires a lot of research to figure out. Indications are that electrical may also be an issue. • Supplemental (miscellaneous) steel to support pipe and tray supports is not yet designed which results in change paper to get it fabricated and installed. • Two-inch diameter and under conduit/piping is field routed. Recommendation(s) • Engineering should get ahead of construction and get E&DCRs incorporated into design drawings so that construction planning is simplified and takes less time. • A construction priority should be work package closure. • The Strategic Planning Group function should continue because of the issues that have been identified to date with the engineering design drawings. • Set up in the field a design engineering "light structures" group to facilitate field walkdowns to support preparing designs for 2" diameter and under support designs, and issue the design drawings.
E11	Observation(s) Based on discussions with SCE&G engineering and licensing personnel: • SCE&G does not believe WEC engineering is ahead of construction. • WEC has limited civil/structural resources in their Cranberry office to deal with the civil licensing issues and is not as knowledgeable of ACI 349 as the NRC. • SCE&G believes there will be more emergent civil issues, e.g., construction tolerances. • The piping Design Acceptance Criteria (DAC) ITAAC may become a potential problem area. The Consortium has to inform the NRC when piping stress analyses are complete so that NRC can inspect them. • SCE&G expects problems with digital I&C. Recommendation(s) • No specific recommendations.
E12	Observation(s) • Module design was not complete at time of contract execution. The change from A36 to A572 steel created fabrication issues. • "As assembled" final module tolerances are driven by ITAAC requirements. Fabrication tolerances had to be tighter to meet 'as assembled" tolerances. • Different tolerances are specified for different modules. • Fabricators are finding design errors.

Table 3-1. Engineering Observations and Recommendations	
No.	**Description**
	• Some large mechanical modules are complex and not yet fabricated. • The WEC site team supports onsite module work. WEC Cranberry supports in shop module fabrication. Recommendation(s) • Correctly sequence the placement of mechanical and floor modules into Unit 3 CA20 and CA01 modules prior to installing them in the unit.
E13	Observation(s) A significant number (greater than 1,000) WEC drawing holds exist that are impeding procurement and construction activities. Recommendation(s) • As part of the weekly schedule update meeting, review near term holds and commit to getting a release date for hold removal and document issue to support procurement and construction work.
E14	Observation(s) • The to-go WEC engineering schedule comprises roughly 75-85% activities that are 'software' only; i.e., closing out corrective actions, rolling in outstanding E&DCRs, archiving calculations, etc., most of which is required to support fuel load, not the day-to-day construction work. • The Post-Engineering Design Closure Plan is meant to be that engineering work necessary to get the plant to fuel load, but is not necessarily tied to immediate construction work; e.g., hot functional testing plan, SIT/ILRT testing plan, engineering support to startup; piping and supports as-built reconciliation; structural adequacy evaluation, document turnover to the Owner, etc. WEC is working to develop the work scope, schedule, and resources required for completing or supporting these activities. Recommendation(s) • Continue with the weekly schedule review meetings to ensure these engineering activities are getting completed in addition to supporting emergent site issues and completing any unfinished to-go design engineering. • Assemble a team of subject matter experts to develop the work scope, schedule activities, and resource requirements for Post-Engineering Design Closure. This will enable determination of the need to add resources later in the project or to reassign personnel to support these work activities.
E15	Observation(s) Personnel assigned to the onsite document control team are working significant overtime. Two document control staff persons were recently added and an additional member may be added in the near future. The document control team is challenged with the volume of work necessary to support work packages and drawing maintenance. Recommendation(s) • Perform a review that leverages the experience of current team members who have worked other commercial nuclear sites and develop a "best in class" approach to document control. Alter work processes to incorporate the things that worked well at other locations and avoid the

Table 3-1. Engineering Observations and Recommendations	
No.	**Description**
	mistakes that may have occurred elsewhere. Encourage a questioning attitude among team members that allows the question, "why are we doing this?" to be asked of all phases of the document control process. • Implement the use of bar coding to reduce the amount of time craft personnel spend in re-trieving and submitting work packages.
E16	Observation(s) • Based on discussions, site document control has a challenging task to meet existing work package demands, though, from discussion, it appears that electronic processes do assist in package processing and production/reproduction. Document control is staffed with fourteen (14) workers, providing coverage 24 hours per day for six (6) days each week, with staff on call for Sunday work. • The work control process places a significant administrative burden on those developing, maintaining, and administering work packages. Field work portions of the packages contain numerous sign offs, requirements for shift work accomplishments to be documented, etc. These requirements begin once a package has been picked up from document control at the beginning of a shift, transported to the work site, pre-job brief performed, and work allowed to begin. At the end of shift, the package is returned to document control, where entries/updates provided during the shift are documented. The next shift continues the process when the shift representative picks up the package to begin the next phase of work. Recommendation(s) • Continue the cross functional team identified by the Consortium that is tasked to review the work control process (including document control) and include consideration of the following items: — Reducing the volume of paper in work packages — Minimizing worker entries to those absolutely necessary to document work performed — Implementing alternative means of making worker entries (electronic tools) — Performing field assessments of work package activities to include worker/foreman feedback/suggestions — Eliminating documentation not specifically needed in the field for workers to perform work — Developing work packages for smaller, more discrete work scope.

4. Procurement

This section describes the assessment of the procurement aspects of the project. Section 4.1 provides a summary of the current status. Section 4.2 provides procurement observations and recommendations.

4.1 Current Status

The project is supported from a procurement perspective by CB&I and WEC, with CB&I's efforts supported both onsite and in their Charlotte, NC offices and WEC supported by their Cranberry, PA offices.

The project procurement teams are focused on the to-go purchases and material deliveries as reported via the ROYG report and discussions with site personnel. The September 28, 2015 ROYG report provides the following information regarding the to-go purchases and the delivery status of components tied back to the schedule:

Category	WEC Remaining POs to be Placed	WEC Remaining Equipment Delivery	CB&I Remaining POs to be Placed	CB&I Remaining Equipment Delivery
Red	6	54	17	1,159
Orange	2	29	7	218
Yellow	1	27	1	143
Green	22	347	0	1,387
N/A	--	--	2	0
Total	**31**	**457**	**28**	**2,907**

Currently, the procurement portions of the ROYG report do not accurately reflect the project's current requirements or needs. Bechtel' ability to properly assess the impact of the above data in relation to the project critical path was hindered because CB&I was completing a schedule adherence project. This effort, scheduled for completion by October 31, 2015, is planned to result in changes to the ROYG report to properly identify material requirements that do not support the project schedule. Once these changes are identified, the Consortium plans to implement mitigation plans to resolve identified problem areas.

CB&I site procurement is focusing on several efforts which are of importance and in various stages of completion:

- Establishing and fully implementing a min/max strategy and program that supports construction needs. There are eight permanent plant material blanket purchase orders (BPOs) in place and an additional 16 in process with forecasted awards dates. Coordination with construction is needed such that identification of material(s) is made so that BPOs can be put in place with appropriate min/max levels established based upon

construction's requirements and usage rates and supply lead times. This is key to implement an effective program that supports the project's daily requirements.

- Inventory validation of material under the control of CB&I procurement, which currently has a 48% level of accuracy.
- Warehouse and laydown area availability and proper utilization.
- Commercial grade dedication (CGD) program implementation and adherence.

Overall, the current Consortium procurement program has the basic procedures and processes in place to complete the work. There are, however, areas for improvement and potential risks that are identified in the sections below.

4.1.1 Supply Chain Commitment and Support

Industry-wide, the nuclear supply chain continues to be in a period of restart and growing pains. Although the Consortium has nuclear quality programs in place, they are still adjusting to the existing and new regulations and documentation requirements. There has been a learning curve that is still in progress. The challenge is to keep the supply base in such a form as they can be profitable and provide a product or service at a competitive price.

The Consortium is challenged with the amount of design changes and documentation, which has presented commercial issues that have to be dealt with and resolved. The Consortium must be cognizant of and sensitive to supply chain issues, as they need to see that nuclear power requirements will not negatively impact their ability to do business.

4.1.2 Commercial Grade Dedication

Commercial grade dedication (CGD) is an accepted and necessary element of the nuclear supply chain. The issue is compliance with the requirements and the supply chain's understanding of their responsibilities as conveyed in the commercial agreement between the project and a given supplier or contractor. Additionally, the conveyance of project specific requirements is critical to the proper implementation.

There have been concerns with the proper conveyance of project requirements to the supply chain and their understanding of the project's needs. On the Consortium side, it was conveyed that there was a lack of understanding of the CGD process and management thereof. This was evident in the supply of safety related fabricated end beds. These concerns have been identified and are being addressed, with the result being improved awareness of project requirements by the suppliers and applicable project personnel. The key point here is the need for Consortium and supplier personnel to fully understand the CGD requirements and processes. There must be continued focus with this effort for the timely delivery of material and equipment to the project in accordance with construction need dates.

4.1.3 Preventative Maintenance Program

The implementation of and adherence to a robust preventative maintenance program is critical to achieving schedule compliance. With equipment and material deliveries currently onsite and not being issued to construction, the required preventative maintenance must be conducted and properly managed. This is a recognized concern and is being addressed by the construction and procurement departments. The focus and timeliness of adherence to programmatic requirements must be enhanced. It was observed and recognized by the CB&I procurement team that attention to this process was lacking and that the project needs to dedicate the resources accordingly. For material to be in support of the construction need date, it must be in compliance with both the technical requirements as per the purchase specification and the supplier-recommended maintenance program. If these are not followed, the construction need dates may not be met due to required repairs or complete replacements. Thus, preventative measures must be scrupulously followed to ensure that the schedule is not affected.

4.1.4 Documentation

The required documentation (certification packages with shipments), as it relates to the material supply, is one of the key elements of the final turnover package to the Owner for permanent plant retention. In discussions with the CB&I procurement team, it was described how errors are continuing to be identified in the required certification paperwork. These errors should have been caught either by the supplier or the CB&I inspector reviewing the packages prior to shipment. It is critical that the supply chain and CB&I assigned personnel fully understand this requirement and comply, since the lack of proper turnover documentation can adversely affect the schedule. Further, the project's prompt review of received documentation is critical, because if there are issues with it, they need to be raised and resolved immediately so that the material can be released in support of the schedule.

4.1.5 Storage Facilities

Currently, the site conditions are such that there is insufficient space to properly receive, store, maintain, and manage material. There is a program in place to evaluate this issue, and efforts are underway to expand and manage the outcome. There must to be a concerted effort to complete this effort so that the material management process can become more efficient and timely to constriction needs. Additionally, if material cannot be maintained, stored, and located for issuance in a timely manner schedule will be affected.

4.2 Observations and Recommendations

Procurement observations and recommendations are identified in Table 4-1.

Table 4-1. Procurement Observations and Recommendations	
No.	**Description**
P1	Observation(s) • Observed the need for an enhanced level of communication, so that the site organization knows the detail of deliveries and issues associated with 1x4 material/equipment and module procurements as there are issues that have to be addressed and communicated accordingly. There are multiple meetings at the site in which materials are discussed. Proper and accurate status must be conveyed. • Additionally, from a material management and storage perspective, the status and specifics of deliveries and site need are required due to the limitations of on-site storage. Recommendation(s) • Improve the process of conveying status and associated details of issues such that sufficient details are known and can be properly conveyed. • Establish a coordination meeting for procurement only so that there is a coordinated effort between site and Charlotte procurement activities.
P2	Observation(s) • During multiple walks and drives through of the warehouses, tents, and laydown areas, it is evident that there is insufficient space for level C and D storage. Specifically, there are 38 +/- floats with pipe spools that require the receipt process completed as there are storage issues. • There are currently 16 different locations covering both on and off site storage which are quite spread out over the project site. Additionally, material is being held at the multiple suppliers as there is no place to store at site. Recommendation(s) • Complete a needs analysis to identify and finalize the required space. • Perform a comprehensive manufacturing schedule review against construction need dates and deliveries forecasted for the next 6 months. Work with the supply chain as appropriate to delay manufacture to allow for future shipment at the appropriate time. • Prioritize issues with Level C storage requirements.
P3	Observation(s) During the review of laydown and warehouse areas, it was stated that there was material no longer usable or needed due to design changes, particularly rebar and pipe spools. There is a delay in the process of identifying what material is no longer required and its appropriate disposition, leading to an ineffective allocation of space. Recommendation(s) • Expedite the finalization of the surplus process and implement it quickly so that space can be reallocated to incoming material. • Consortium management must drive this priority activity, along with Owner input, since space is at a premium.
P4	Observation(s) During multiple walk-throughs of the site laydown yards, there is a mix of material within the yards instead of having a program of commodity management by yard. This lends itself to inefficient material handling for a given work package. Having material in multiple locations can result in double handling and present challenges to basic material management.

Table 4-1. Procurement Observations and Recommendations	
No.	**Description**
	Recommendation(s) • Recognizing that this will be a significant time, resource, and logistical issue, work to reorganize the laydown yards with a focus on incoming material. Work towards staging by commodity and, where it makes sense, by work package.
P5	Observation(s) • Inventory validation is currently at a 48% accuracy level. This level of inventory control lends itself to not knowing where material is or what is in stock, resulting in the withdrawal process being time consuming. • Further, for bulk type items, construction doesn't know what's on hand; thus, their ability to plan is hindered. It was evident that with the current situation, material is just reordered as it is not known if it was onsite, used, etc. Recommendation(s) • Complete the inventory revalidation effort which is planned for completion by the end of 2015. • Establish a program to continually validate inventory.
P6	Observation(s) • During multiple walk-throughs of the CB&I laydown yards, the majority of pipe spools for identification purposes have paper tags rather than metal tags. It was observed that with the time material is held in laydown yards the paper tags have deteriorated or detached. • It was observed that some radio frequency identification (RFID) tags have also become detached. It was conveyed that, with the extended storage durations, they are experiencing failure of the RFIDs, which necessitates their replacement. Consequently, material identification and location is problematic. Recommendation(s) • For material currently in CB&I's control, as part of the re-inventory process, create and attach new tags. Use weather resistant type tags that can be printed onsite. • For future shipments, CB&I Laurens must use and attach metal tags instead of paper. It is assumed that a specification change will be needed to facilitate this new method of identification. • As part of the re-inventory process, validate RFID operability and change accordingly if required.
P7	Observation(s)] In regards to material management and associated preventative maintenance requirements, it was observed that with the extended storage period for material in the onsite laydown yards and warehouses, there are deficiencies with the management and the administration of that process and the need for additional focus in this area. With the lack of proper management, i.e. maintenance, there is the risk that if material has to be replaced for whatever reason, there is the potential for a schedule issue since the replacement lead time may not support the schedule. Recommendation(s) • Enhance the material storage program such that it is properly monitored and maintained as a joint effort between procurement and construction. • Reconfirm that all items requiring maintenance are properly included in the material storage program. • Identify and disposition items that have issues/problems quickly so that if replacement or repair is

Table 4-1. Procurement Observations and Recommendations	
No.	**Description**
	required, the replacement properly supports the schedule.
P8	Observation(s) • There is a material management min/max system and process in place, but it is not fully developed. • Currently, there are eight permanent plant and 24 non-permanent plant (16 of the BPOs are associated with civil products); and 16 permanent plant BPOs in the schedule for establishment. The use of these BPOs is not fully implemented and used by the project. • All requisitions are screened for material that may be in the system. Recommendation(s) • Expedite the implementation of the identified BPOs so that construction can use them rather than writing individual material requisitions. • In developing the "list" of BPOs in place that would support a min/max system, construction and field engineering personnel should help define what products should be maintained within the min/max system. • Educate site personnel on the use and process of the BPOs and the min/max system.
P9	Observation(s) • In discussion with the materials team, there was a lack of planning and coordination for material requests/withdrawals. The majority of material requests come in as a "rush". • Material requests generally are generally not submitted to procurement with any lead time, coordination, or planning, which results in an inefficient method of operation. • Work is performed by work package, and materials are scheduled in accordance with the schedule. Recommendation(s) • Work with construction and establish a "planning tool" such that the two organizations better communicate needs so that requests are not in a continual rush mode of operation. • Establish a two week look-ahead planning tool. This is needed as material for a given request is most likely in multiple locations with the current laydown yard situation. • Consider storing material by work package, as this will make withdrawal more efficient and act as a confirmation that all material is on-site and available.
P10	Observation(s) • In reviewing schedule status reports and in discussions with procurement management, it is unclear if all options have been exhausted with respect to sources of supply and allocation of work to a given module fabricator. CB&I is analyzing work allocation based on current performance, shop loading, and construction schedule needs. • It was said that this activity is complete and that the distribution and proper allocation of work has improved. Additionally it was stressed that the performance of assigned fabricators was improving. With the past performance of the fabricators along with design changes, intrusive management of these fabricators is needed. As these issues are of a commercial nature, Bechtel did not see the details. • Based on a review of the September 28, 2015 ROYG report (Item 15.16), there are multiple deliveries in the red indicating that they do not support the schedule.

Table 4-1. Procurement Observations and Recommendations	
No.	**Description**
	Recommendation(s) • Continue to analyze work allocation based on current performance, shop loading, and construction schedule needs. • Confirm the ability of the existing eight module fabricators to support the schedule with the resources, flexibility, and wherewithal to handle the work. • Complete an analysis of the ROYG report (Item 15.16) and their associated fabricator and develop a plan to have deliveries made in accordance with the schedule.
P12	Observation(s) • There is an issue with compliance with project and Purchase Order requirements to support the accuracy of required documentation. This issue seems to cross all of the procurement activity. • CB&I's process stipulates reviews and accepts documentation packages at the supplier's facilities, as appropriate. Recommendation(s) • Reconfirm that Purchase Order and/or Contract requirements are clearly and properly stated. • Re-review with the supply chain their understanding of requirements. Monitor for trends and address with supplier management. • Address the training of individuals reviewing documentation packages to ensure their understanding of the requirements and processes.
P13	Observation(s) • In general discussions with CB&I's procurement manager on risk items, a lack of overall effort and focus was observed. Items are identified but it is not clear how diligently CB&I is managing these risk items to closure. • Risk Register Item #67 –Critical Equipment/Vendor Supply and Oversight – is still under development and owned by site procurement. Recommendation(s) • Hold procurement accountable to close risk items as scheduled.
P14	Observation(s) • After meeting with CB&I's procurement manager, there appears to be a workable process in place for managing purchasing, expediting, and materials management activities that has evolved as the project has grown. The observation is whether there are enough resources applied to properly monitor/manage activities. • Additionally, design changes were a recurring topic of discussion regarding the management of the current eight agreements for module fabrication. When looking at the ROYG procurement report, there are multiple modules that are in the red. Recommendation(s) • Complete the analysis of ROYG report to properly assess the schedule. Ensure proper attention/monitoring is in place. • Reconfirm the expediting resources available to manage the fabrication Purchase Orders and improve schedules. • Improve the efficiency of change management, as it takes too long to resolve issues that will allow completion of fabrication.

Table 4-1. Procurement Observations and Recommendations

No.	Description
P15	Observation(s) • In discussions with all groups, the subject of CGD was brought up and the concern of the project requirement being properly conveyed and the supply chain complying and knowing "what to do". • Further, with the evaluation process being time consuming and with the current submittals under review from suppliers and resulting outcome, the effect is unknown. Recommendation(s) • Expedite the resolution of CGD issues so that if the material has to be replaced, it can be in time to support schedule. • Revalidate the Purchase Orders that have compliance issues so that verification is documented and all material is accounted for. • Increase the interactions with suppliers to ensure the Purchase Order/specification requirements are understood and CGD is properly supported by the supplier and project engineering.
P16	Observation(s) • CB&I uses the Smart Plant operating platform as their requisitioning tool onsite. This program appears to be functional from the creation and routing of a requisition through to the assigned buyer and subsequent award. However, there is no expediting module within Smart Plant, thus the tracking of open Purchase Orders is done manually via an Excel tracker, and there is no mechanism in the system for an individual to look up the status of an open Purchase Order. • It was also noted that the ability to track requisition/Purchase Orders by work package was not available; this function was also done manually. The issue here is that an item must be tracked manually rather than using the system, which is an inefficient means of monitoring materials and assuring all material is accounted for in a given work package. • It was noted that the site procurement team has manually created status reports that track open orders and are used with their coordination with construction. Recommendation(s) • Expand/enhance existing tools to accommodate site needs, such that status data can be maintained and available for view by the project. • Develop a system whereby data management/entry is completed within one system.
P17	Observation(s) Review of the ROYG report shows the following: • CB&I procurement management described that they recognize this data is not correct in the ROYG report. A "schedule adherence activity" (project) by discipline is currently underway for the

Category	WEC Remaining Equipment Delivery Count	CB&I Remaining Equipment Delivery Count
Red	54	1,159
Orange	29	218
Yellow	27	143
Green	347	1,387
Total	**457**	**2,907**

Table 4-1. Procurement Observations and Recommendations	
No.	**Description**
	past 8 weeks, as there are activities that are not correctly tied, thus the data in ROYG is incorrect. • The schedule adherence project was to be completed by October 31, 2015 and is expected to result in clear visibility as to what commodity/equipment requires a mitigation plan from an overall perspective versus an emergent need on a daily/weekly/monthly basis. Thus, as of the writing of this report, the use of the current ROYG report data is not useful in the schedule analysis. Recommendation(s) • Complete the schedule adherence effort as planned by October 31, 2015. • Evaluate resource needs to properly manage items identified in the ROYG report as impacting construction need dates.
P18	Observation(s) In discussions with the site procurement team regarding work package planning (creation/issuance), it was observed that late issuance translates into late requisition creation and the need for material to support construction need dates turns many procurements into a "rush" situation. The planning and issuance of work packages is out of synch with the procurement cycle and inhibits the procurement and delivery of material in an orderly manner. Recommendation(s) • Adjust work package planning to allow for a "normal" state of operation for the downstream activities after the work package is issued.

5. Construction and Project Controls

This section describes the assessment of the construction and project controls aspects of the project. Section 5.1 provides a summary of the current status. Section 5.2 describes the analysis of the project construction schedule. Section 5.3 provides construction and project controls observations and recommendations.

5.1 Current Status

5.1.1 Introduction

As part of the assessment, Bechtel's construction and project controls personnel gathered a wide variety of information on the history and current status of the effort, such as:

- Reviewing organization charts
- Touring various areas of the site (e.g., Units 2 and 3 nuclear islands, turbine areas, module assembly building (MAB) and laydown areas, temporary facilities)
- Reviewing schedule information, including indirects, bulk quantities, installation curves, manpower curves, and weekly/monthly reports
- Attending safety meetings, plan of the day (POD) meetings, module status meetings, and area schedule meetings
- Meeting with a number of individuals to understand the work packaging program, quality organization, project controls organization, engineering status, procurement program, constructability and strategic planning, startup and turnover plan, and the document control process
- Holding meetings to understand shield wall installation schedule, management of indirects, craft recruiting (industrial relations), and raceway and hanger installation challenges.

Early in Bechtel's assessment, the Consortium presented to Bechtel their organizations and the status of and the plan for the project. The Consortium provided Bechtel the estimated bulk quantities for installation, as well as the budgeted jobhours and performance to date by general account (such as concrete, piping, and electrical; but no further breakdown). The Consortium would not, however, share the unit rates. Without the unit rates, the Bechtel estimate of the jobhours needed to complete the project is based on Bechtel's historical records and estimates of work activities observed during their assessment.

It was apparent that contractual issues between the parties are impacting the work. Timely resolution of problems does not seem to have the quick response needed by the project to achieve the schedule.

The project can be proud of its safety record, especially the months of August and September 2015 where the project had only one recordable each month. The cleanliness of the site and work areas really stood out during Bechtel's walkdowns.

Some of the primary contributing factors to project performance include:

- Working too many hours for an extended period — the work schedule is a 58 hour work week (5–10s and 1-8) with selected overtime
- Non-manual turn over — the rate for the year to date is greater than 17%
- Amount of time the craftsmen are at the work face — numerous issues are keeping the craftsmen from performing work
- Engineering design changes during construction and slow resolution of issues — work is continually being impacted
- Organization at site — The Project Management Organization (PMO) and the Operations Control Center (OCC) are set up to treat the to-go work like an outage, with status of the next week's work reviewed on a daily basis
- Use of modules — While a great idea in theory, their use so far has been a detriment to the project progress and consequently the budget
- Construction of nuclear plants today is different from the previous generation in the 1980s. It doesn't appear that all the new requirements were included in the estimate.

5.1.2 Construction Staffing

The project is heavily into the civil phase of the work, with concrete approximately 30% complete and structural steel approaching 20% complete. The piping and electrical bulk installation has just begun, with only a small amount of pipe in the turbine building being installed. The current construction staffing levels are approximately:

- Supervision — 85
- Field engineering — 290
- Direct craft — 800
- Indirect craft — 1,100

With only 800 direct craft, the supervision and field engineering ratio to craft is at present quite high. However, it is expected that when the craft staffing level peaks at approximately 4,000 (i.e., a Bechtel estimate), the ratio will be at the appropriate level if the number of non-manuals increases marginally.

5.1.3 Schedule Continues To Slip

A revised schedule was issued in January 2015, and since then the schedule has slipped significantly. The continuing problems with the modules have been a big part of the reason for the

schedule slippage. Impacts from late design changes have also impacted the work. A large number of interferences have been identified and the time it takes to resolve those interferences as well as other problems such as construction errors has had a significant impact on the schedule. In addition, the concrete portion of the shield building is complex and has impacted the schedule.

There are plenty of work areas available to work, but the current staffing level will not support their needs. In an effort to improve accountability on the project, the Consortium recently introduced a Project Management Organization and an Operations Control Center. These organizations have meetings every day, and although they are improving the accountability and problem resolution, the time that the construction management personnel spend updating the issues discussed is impacting their ability to be out in the work areas. Finally, non-manual turnover is running at greater than 17%, which is impacting the morale on the project as well as the schedule.

5.1.4 Major Issues Affecting Schedule and Performance

There are a number of major issues that are having significant impacts to the schedule and the performance of the project, as described below. The Observations and Recommendations section also provides additional details.

a. Working Too Many Hours for an Extended Period

A large percentage of the personnel on the project have been working 58 hours (5-10s and 1-8 hours per week) for an extended period of time. One of the reasons given was that the overtime is used to attract the craftsmen (the project is advertised as a 48 hour work week). While overtime is used to attract crafts, the project pay scale is competitive with most non-union projects in the Southeast U.S. CB&I is presently struggling to attract rebar ironworkers and will have similar problems with pipefitters and electricians (there will be 2 to 3 times as many pipefitters and electricians as ironworkers) when the project is heavily into the bulk installation.

There are other ways to attract craftsmen besides overtime. Incentive programs have been developed, such as providing an incentive of $1/hour for craftsmen staying until given a reduction in force, which would lower the almost 20% of craft resignations year to date. A lot of time and money is expended getting the craftsmen on board, and an incentive program like this would help retain them.

CB&I is considering increasing the amount of overtime in order to gain schedule. Numerous studies by the Construction Industry Institute, Business Roundtable, Department of Labor, and the trade unions have shown that when extended overtime is worked more than 8 to 9 weeks, the performance deteriorates quickly resulting in a 58 hour week approaching the performance equivalent of 40 hours. The costs definitely outweigh the benefits of this approach, for in addition to reducing productivity, extended overtime also negatively affects morale, decision making, and safety.

b. Significant Non-Manual Turnover

The non-manual turnover for the last year has been greater than 17% which is high for a typical nuclear project. In particular, the Unit 2 Nuclear Island has had five different managers since the start of the project. There are a number of issues contributing to the turnover; most pressing is CB&I's difficulty in finding experienced, qualified people. While they have been hiring some of the older and experienced people who worked on nuclear power units back in the 1980s, many of these individuals are now in their 70s and this type of construction is better suited to people that can spend entire days on their feet moving from one work location to another throughout a normal work day.

Many of the non-manual personnel expressed frustration and being "worn out" due to the amount of overtime they put in to meet the job demands, as well as having to meet the informational requirements imposed by the PMO and the OCC.

Managers and supervisors working on a nuclear power plant are under constant stress. The safety, cost, and schedule concerns never cease; and when these are compounded with the frustrations of design changes, Owner demands, worker complaints, and the difficulties of achieving installation work, the stress is great, creating turnover issues.

c. Craftsmen Time at the Workface

Because of the requirements of the project, the craftsmen are not able to spend a full workday at their place of work. There are many factors involved, but the biggest one seems to be the Work Package (WP) procedures. For example, most concrete WPs include three volumes with each volume being three or more inches thick. One volume has safety bulletins, quality control signoff sheets, and general information associated with the work; one has drawings and specifications; and one has design changes. In some packages, the design change volume is twice as thick as the drawing volume.

Each day the foreman must check out the WP from document control and take it to the workface. If there had been a change to the WP in the last 24 hours, the package is put on hold until the field engineer can locate the change document in the package and replace it. If the field engineer is not available immediately, the foreman must wait to check out the WP until the field engineer is available. As a result, no work is performed until the WP is updated.

We observed the start of the work shift and it took approximately an hour for the craftsmen to start work. Further, the craftsmen leave the work area for both coffee breaks and lunch. Arrangements should be made to have the crafts stay in the building during coffee and lunch breaks.

It is a common practice to transfer craftsmen from one area to another to provide support, as needed. This is usually done on an occasional basis, after which they return to their original work location. Because of the project schedule pressure, these transfers have become standard practice, leaving some work areas (for example, the Unit 3 nuclear island) with a management

team that has few craftsmen to perform the work. The present difficulty in recruiting rebar ironworkers just increases the problem. Combining Unit 2 and 3 nuclear island non-manuals might help solve some of these issues.

At this phase of construction, as elevations in the buildings are completed, there is usually space to allow the craftsmen to locate "gang boxes" and storage boxes on each elevation, so the tools needed for the work are located near the work area. Because of the ongoing module work and the small footprint of the buildings, some workers are required to carry their tools to the work area every day. If they find they need something they did not bring, they have to leave the building to get it, which is another cause of time away from the workface.

d. Engineering Design Changes and Slow Resolution of Issues

A large part of the schedule slip is related to late design changes, slow resolution of interference issues, and the time it takes to resolve construction errors and quality problems. A large number of these issues are related to module construction. Many of the changes come at the last minute, which requires the construction group to revise their plan, which can have a significant impact on the work. In addition, changes are not being incorporated into the drawings in a timely manner, causing the craft to spend a good deal of time confirming they are working with the latest information.

When questions arise due to design interferences or an engineering analysis of a construction or quality problem is needed, it appears that either there are not enough engineering resources to address the issue, or the issue is not addressed with the urgency needed to keep schedule and cost impacts to a minimum. Apparently, there are a number of minor issues that used to be resolved by field engineering, but now require design engineering resolution. For example, each stud bent more than 15 degrees requires a design engineering resolution – this is just one example out of hundreds. Construction has developed a generic guidance document to have design engineering provide some standard procedures to address many of the minor issues. However, a review of the issues requested indicates design engineering could provide more relief to construction if more effort was spent in analyzing the issues. In addition, some of the responses construction has received seem to be much more complicated than necessary (e.g., the missing dowels from containment pour 4 which had to be drilled and grouted in). A loosening of installation tolerances would be one area that could provide construction with some significant benefits.

Construction has initiated a constructability review and a strategic planning effort which reviews the design to identify interferences and determine if there are constraints to the work. This should help drive down the number of interferences that affect work schedules.

As long as there are late design changes occurring and there is not expeditious resolution of issues that arise, there will continue to be significant schedule slippages.

e. Site Organization Impacts

The PMO meets daily in the POD meeting with site senior personnel to review near term work and review the progress (or impacts) made in the last 24 hours. The OCC meets daily with area superintendents to review the 3-week look-ahead schedule to determine progress against the schedule and identify issues that may affect it. Both of these efforts are run similarly to the method used for short term operating nuclear plant activities, such as a refueling outage or completing startup work. There are some real benefits to this approach, such as identifying what is holding up the work and determining where to focus the efforts to overcome those barriers. However, there is also a big downside to using this approach on a large construction project that is still in the civil work stage, as it causes a large number of resources to be occupied with providing daily updates instead of focusing on the work in the field.

A large project such as V.C. Summer is divided into areas, so that area teams can take full ownership of the scope handled in that area. Assistance in resolving issues (which the PMO provides) allows the team to focus on the work, but it should only focus on resolving the engineering, procurement, and quality impacts and hold schedule meetings once or twice a week. Having a daily schedule meeting which the OCC presently does, requires a lot of time and detracts from the focus required to get the construction work done. If the PMO wants to address the construction progress, they can do so in the weekly schedule meeting.

In May 2014, a management decision was made to set the CA20 module in the auxiliary building even though the module fabrication was not complete. Completion of the module is not expected until the end of this year, and doing this work in the building has had a significant impact on the cost and the schedule to the project. The module should have been left in the MAB where there is a controlled environment and access to the module is much easier using man lifts and scaffold. Had it been left in the MAB until assembly was complete, one would expect that some of the schedule slips this year would have been mitigated.

f. Changes in Current Nuclear Power Plant Construction Versus the 1980s

In the 1980s, the building boom for nuclear power plants was coming to an end. The boom had started in the 1960s, so there were many experienced craftsmen and non-manuals available, some with 20 or more years of experience. There were also numerous nuclear equipment suppliers and multiple engineering and construction organizations.

The normal practice then was to start engineering and within a few years, start construction while engineering was ongoing — usually keeping a step ahead of construction. Construction had lots of input into the design, ensuring that the project was "construction friendly". The plants were built under the Construction Permit/Operating License approach of 10 CFR 50, so proceeding with construction "at risk" was a common practice. Field engineering had the authority and latitude to resolve many of the issues that arose during construction.

At V.C. Summer, a standard AP1000 design is being built that is planned to be used on numerous sites. In comparison to the nuclear power plants of the 1980s, the AP1000 has reduced quantities, encompasses a smaller footprint, and uses modules extensively. However, the reality as experienced on V.C. Summer has shown some issues with this new, modernized design. The modules, while a great concept, have proven to be an impediment to the construction and are much more complicated to fabricate and install. While the quantities have been substantially reduced along with the footprint, in some areas the density of the material in the area has increased, resulting is a more difficult installation and an increase to schedule. While designing the plant in multiple locations, it appears that the coordination between those groups was inadequate in some instances. It also appears that few constructability reviews were performed, resulting in many interferences and difficulties with the construction.[3]

Experienced craftsmen and non-manuals will continue to be hard to find. Efforts are going to have to be made to train them and find ways to make their jobs easier. The project has an extensive onsite training facility that is capable of training individuals to become most any craft. Recently, 13 laborers were trained to become rebar ironworkers where they currently have a shortage. The training program needs to be expanded and kicked into high gear to start developing pipefitters, electricians, welders, and more rebar ironworkers. WP procedures need to be reviewed to make it easier for the craftsmen to spend time at the workface.

5.1.5 Key Schedule Challenges

a. Staffing and Productivity

A significant project challenge is obtaining the craftsmen and getting them productive. At present, the project is challenged to obtain enough rebar ironworkers and in the future, the challenge will be obtaining the large number of pipefitters and electricians in the not-too-distant future. Currently there are several areas where there is workable backlog (e.g., only 100 craft in the Unit 3 containment, several elevated floor slabs in the Unit 2 turbine building where rebar could be installed, and no work in the Unit 3 turbine building). Over the past several months, the project has been achieving a 0.5% progress per month when the Consortium's schedule requires 1%. The project needs to work the available workfaces to increase the progress. The future needs are 2.5% to 3% per month. The industrial relations group needs to get out in front with training and obtaining the craftsmen needed.

The project has several requirements of the craftsmen that keep them from the workface, and these need to be addressed. The WPs need to be simplified in order to provide the foreman only the information required to accomplish the work and have quality control sign-offs. At present, the WPs include safety information that duplicates the weekly safety bulletins, the specifications and standard details, and too many design changes without updating the design drawings. The WPs, in some cases, are three inch binders, when the package the foreman needs is less than 1 inch thick. The morning safety bulletin requires each member of the crew to sign the back of bulletin; it takes 15 minutes for a crew of ten to review and sign the bulletin. Thus, it takes over an hour each

morning to get the crews to the workface. A senior construction person should work this issue with the goal to getting craftsmen to the workface sooner, thus becoming more productive.

The overtime, 5-10s, and 1-8 plus selective overtime needs to be reduced to no more than 4-10s and 1-8 so both craftsmen and non-manuals can be more productive. After 8 weeks of 60 hour work weeks, studies have shown that in actuality only 40 hours of work is really being produced.

b. Non-Manual Turnover

The non-manual turnover is too high to build a productive organization. There have been five different area managers in the Unit 2 containment since the project began, and all the area managers' names have changed since the first of the year except one. Reducing the overtime should reduce personnel turnover.

c. Current Forecast

A new forecast with realistic unit rates and the latest quantities needs to be developed so accurate craft staffing needs can be forecast. Once a good unit rate base is established, the craft and their superintendents need to be held accountable for weekly cost (jobhours per unit of work) performance. At present, not enough attention is given to craft performance. The indirects need to be evaluated and burn down curves developed. The ratio of 1,100 indirect craftsmen to 800 direct craftsmen is not typical.

d. Engineering Changes

Another major challenge is the amount of engineering changes due to interferences when installation is underway; these require engineering evaluations which take a good deal of time and affect craft productivity. Until this impact can be reduced, the craft productivity will continue to be impacted and the schedule will continue to slip.

5.1.6 Assessment of Project Controls Organization and Tools

A successful project controls platform requires competent team members, a project controls plan, and strong EPC integrated project management tools to track project progress and performance. It was identified over the course of the assessment that the Consortium's project controls team is competent and does have the appropriate level of experience required to manage the project. Inversely, the Owner's organization lacks the appropriate personnel to provide the proper level of review and oversight required to drive the project to successful completion.

Bechtel's assessment was focused on the schedule aspects of the project only. Cost was reviewed solely in terms of hours and productivity. In general, the project management tools that are in place to track the schedule are sufficient, but in some cases the processes and data used require change. For example, the Consortium's bulk installation curves include both below and above ground commodities within the same curve. The bulk curve tracking tool itself is

appropriate, but the results become suspect when combining these commodities. Since the underground activities occur significantly in advance of the above ground, the calculated sustained duration window is extended creating false results for evaluation of achievability.

The primary scheduling tools reviewed included the bulk installation curves, Level 1 schedule, and Primavera Level 2 & 3 schedules. Each of these items is addressed within the observation and recommendations identified in Section 5.3. In summary, these tools appear to contain the majority of procedural requirements and are deemed acceptable. The issues that exist with these tools occur within the data or level of tracking detail. Overall, the integrated project schedule contains the entire scope of the project. The issue is the appropriate level of detail contained at each level of the schedule.

- The Level 1 schedule lacks the appropriate level of detail to be considered a useful tracking tool. It only contains some of the required dates and the overall logic sequence is not well represented, nor easily understood by the reviewer.
- The Level 2 schedule within the Primavera tool is only a roll-up of the also included Level 3 schedule residing within. These rolled up Level 2 schedule activities, otherwise known as "hammock" activities, have a limited usefulness due to the extended durations caused by inactivity areas within a logic string. The Consortium's Level 2 schedule, which uses the before mentioned "hammock" concept, reflects the typical parallel activities which hide critical logic ties resulting in a tool with limited usefulness.
- Unlike the Level 1 schedule, the Level 3 schedule includes a massive amount of detail. Bechtel's experience is that an appropriately sized Level 3 schedule, without the working level schedule details included, results in a more efficient and accurate tool to monitor the overall project. For V.C. Summer, the Consortium has included their Level 5 working level schedules, within the Primavera Level 3 database. This results in an overall EPC Level 3 schedule containing over 250,000 activities. Maintaining a schedule of this size takes a great amount of effort and its accuracy can be questionable. The time taken to maintain the schedule also detracts from other areas of the planning process which in most cases is more effective than the detailed schedule updates. This practice can also create a short sighted view with a loss in focus of what it takes to complete the overall project.

5.2 Analysis of the Project Construction Schedule

This section describes the process used by Bechtel to evaluate the project baseline construction schedule's most likely outcome. The current status of the project's to-date performance and percent complete by area were used as a starting point. Bechtel's past performance (21 completed nuclear units) plus four new reactor projects in the planning phase were used as predictive metrics for to-go activities. (It is noted that past nuclear power plants were constructed in accordance with 10 CFR 50 construction permits and not 10 CFR 52 combined licenses.)

5.2.1 Process Steps

The primary steps of the schedule analysis process are identified below.

1. A Level 2 baseline schedule was created from data included within the Consortium's Primavera P6 baseline file (January 2015) and the Consortium's published Level 1 summary schedule.

2. Current forecast bars were added from data included within the Consortium's P6 current forecast file (July 2015) and the Consortium's published Level 1 summary schedule with status through July 2015.

3. A baseline version of bulk commodity curves for each major facility was created from data included within the Consortium's bulk curves.

4. A new "assessment forecast" was created within the newly created Level 2 schedule based on the following:

   - Near Term Civil/Concrete – Forecast start and completion dates were identified based on walkdowns and assessments performed by Bechtel construction personnel.
   - Near Term Steel – Forecast start and completion dates were based on walkdowns and assessments performed by Bechtel construction personnel.
   - Above Ground Large Bore Piping by Area – Initially focused on placement of the 10% forecasted completion mark by area making sure to account for building predecessor logic and current forecast percent complete to-date.
   - Above Ground Small Bore Piping by Area – Set the 10% to 100% forecast dates based on Bechtel's historical relationship logic with above ground piping installation windows.
   - Cable Tray – Set the 10% to 100% forecast dates based on Bechtel's historical relationship logic with above ground piping installation windows.
   - Above Ground Conduit – Set the 10% to 100% start and completion forecast dates based on Bechtel's historical relationship logic with tray installation windows.
   - Cable – Set the 10% to 100% forecast dates based on Bechtel's historical relationship logic with above ground conduit and tray installation windows.
   - Terminations – Set the 10% to 100% forecast based on Bechtel's historical relationship logic with cable installations windows.
   - Major Equipment Erection Durations – Bechtel's historical median durations were used.

5. New assessment bulk installation curves were created with the to-go installation windows set based on Bechtel's median historical sustained rates.

6. The newly created assessment "family of curves" was compared to Bechtel's recommended model. The "family of curves" is a chart containing all of the major commodities scaled by percent complete. These commodities are then compared against each other in relationship of project percent of time. A properly sequenced project will represent itself in installation windows that follow a typical relationship. The installation windows were adjusted as necessary to account for differences as compared to Bechtel historicals.

7. Productivity factored hours were developed based on current performance and input from Bechtel construction personnel by major account (site work, civil, piping and electrical). The newly created unit installation rates were verified against a current, equivalently-sized, Bechtel project.

8. The commodity installation curves were converted into craft hours based on the assessed unit rates.

9. The assessed schedule and unit rate converted hours were used to create craft manpower curves by craft type and facility.

10. Each major facility was reviewed for peak craft loading. Schedule durations were extended where area saturation occurred.

11. Key craft (pipefitters and electricians) unit stagger curves were created for 9, 12, 18, and 24 month staggers between units and evaluated for "best fit" and "most achievable".

12. The assessment manpower curves were converted into percent complete curves. The planned percent complete per month values were compared to Bechtel historical references.

13. The current Consortium's startup schedule was reviewed. The heavily concentrated "turnover and checkout" duration was increased from 12 months to 18 months to account for the following concern in the turnover system waterfall:

    - 2015: 2 turnovers
    - 2016: 44 turnovers (cumulative: 46)
    - 2017: 475 turnovers - 86% of total (cumulative: 521 or 94% of the total BIPs)
    - 2018: 33 turnovers (cumulative: 554)
    - 2019: 1 turnover (cumulative: 555)

The increased duration will allow for a more balanced split between years which ultimately will create a more achievable schedule.

14. The 90% complete dates of each commodity to fuel load durations were set based on Bechtel's historical range data. This will ensure sufficient time to complete startup activities.

15. The assessment schedule logic for the "energization" activity was tied to 65% complete of terminations and the cold hydro activity was tied to 100% complete of nuclear island large bore pipe completion.

16. As a secondary verification method, Bechtel's historical durations were compared against currently forecasted durations driven by logic for the following areas:

- Energization to start of cold hydro
- Energization to start of integrated flush
- Energization to start of hot functional testing
- Start of cold hydro to fuel load
- Fuel load to commercial operation date

17. Reconciliations for sustained rates by area, startup durations by unit, manpower peaks by craft type, percent complete by unit, and overall project duration from first concrete to commercial operation were developed.

18. A limited schedule probability assessment was performed using the Primavera Risk Analysis software. This probability assessment was used to identify the contingency value needed to increase the probability of outcome to the 75th percentile level.

- Because of time limitations, the probability assessment was only performed on the critical path and the top 4 near critical paths.
- A typical 1,000 iteration Monte Carlo approach was used.
- Minimum/maximum windows were identified from Bechtel historicals and input from senior construction personnel on the assessment team.
- Minimum/maximum historical bulk installation rates were used as a secondary verification method.
- Only preferential logic was considered.
- Identification of required contingency was for assessment purposes only.

A more robust probability assessment approach would be needed before finalizing any changes to the project baseline target schedule.

5.2.2 Bases and Assumptions

The primary bases and assumptions for the schedule analysis are identified below.

1. Bechtel's historical reference data includes 21 completed nuclear units and four new reactor projects currently in the planning phase.

2. Turbine generator erection duration is based on Bechtel's average historical installation durations.

3. All activities are worked on a 48 hour work week. A second shift is assumed at 20% of overall directs.

4. During the current civil phase of the work, there are significant productivity impacts resulting from engineering and procurement issues. The impacts during the bulk installation of piping and electrical commodities are not expected to be as extensive; however, some impacts due to future engineering and procurement issues were included when developing the median case schedule.

5. Sufficient quantities and quality of craft are available to support project staffing needs up to a maximum of 3,700 craft.

6. Engineering changes will not affect material availability to support construction installation dates.

7. All modules and materials will be delivered to support construction installation dates.

8. Preventative maintenance will keep equipment operationally ready for installation.

9. The schedule has been developed to avoid craft area saturation levels by building and elevation.

10. The typical historical bulk installation sequence has been altered to account for the following:

    - The north side of the auxiliary building is exclusively electrical commodities which allows for an almost parallel start with piping commodities which are primarily located in the south half.
    - The north side of the annex building is 80% electrical commodities which allows for an almost parallel start with piping commodities. The south side of the building is mixed and will follow the typical bulk installation sequence.

11. The Consortium's bulk commodity estimates by building were used for concrete, steel, large bore piping, small bore piping, cable tray, conduit, and cable with one exception. The Consortium's estimates for conduit and large bore piping in the annex building were not used and are considered unreliable. Schedule extensions to account for these high annex building quantities were not included. The Consortium is in the process of validating these quantities.

12. The Consortium's recovery schedule for shield building installation was being finalized during the assessment and was not available for review. Because of the predicted schedule duration increases in other areas of the integrated schedule, it is assumed that the shield building will not remain on the critical path.

13. The assembly and issuance of work packages will support the construction schedule to ensure work fronts are not limited.

14. There are no construction equipment limitations.

15. The indirect-to-direct craft ratio is reduced significantly from its current ratio of 1.3.

16. ITAAC closures do not impact the critical path.

17. Licensing issues (e.g., the need to obtain prior NRC approval of license amendments) do not limit work fronts or enter the critical path.

18. Cyber security issues do not affect the critical path.

19. Simulator and operator qualifications do not affect the critical path.

5.2.3 Results

The results of the schedule analysis are identified below:

- The to-go scope quantities, installation rates, productivity, and staffing levels all point to project completion later than the current forecast. Bechtel's assessment, based on certain assumptions, is that the Unit 2 and Unit 3 commercial operation dates will extend as follows:

Table 5-1. Impacts on Commercial Operation Dates

	Unit 2	Unit 3
Current COD	June 2019	June 2020
Adjustment	18 to 26 months	24 to 36 months
New COD	Dec 2020 to Aug 2021	June 2022 to June 2023

- The critical path will change from shield building installation to a more typical critical path for power plant projects that includes bulk commodity installations through overall project checkout and testing/startup.
- Increasing schedule confidence to 75% increases the schedule duration by 8 months (included in the 26 months for Unit 2 and the 36 months for Unit 3).
- The stagger between the Units 2 & 3 commercial operation dates is extended by 6 months (from the current 12 months apart to a recommended 18 months apart).
- The peak monthly construction percent complete is reduced from 3.1% to a lesser, more realistic, percentage.
- The primary checkout window is extended by 6 months (from the current 12 months per unit to a recommended 18 months per unit).
- The total craft population is increased by 25% to approximately 3,700. At peak, 850 pipefitters and 730 electricians will be required.
- The bulk installation windows are increased by a minimum of 30%.

Figure 5-1 provides the assessment Level 1 summary schedule. Both the Consortium and the Bechtel assessment schedule activities are shown for comparison. (Figures are located at the end of this section.)

Figure 5-2 through Figure 5-5 provide the mid forecast family of curves for Unit 2 total, nuclear island, turbine island, and balance of plant, respectively.

Figure 5-6 shows the Unit 2 craft manpower and percent complete curves. Figure 5-7 shows the Unit 2 head count by craft (not including subcontract hours). Figure 5-8 shows the Unit 3 craft manpower and percent complete curves.

Figure 5-9 shows the Unit 2 and 3 direct and indirect manpower curves for 12, 18, and 24 month staggers between units. Figure 5-10 shows the Unit 2 and 3 percent complete curves for 12, 18, and 24 month staggers between units.

5.3 Observations and Recommendations

Construction and project controls observations and recommendations are identified in Table 5-2.

Table 5-2. Construction and Project Controls Observations and Recommendations

No.	Description
CPC1	Observation(s) The MAB team has been given responsibility for completing the assembly of module CA03 for Unit 2, which was shipped to the site incomplete, because the vendor could not meet the site need date. They also have several Unit 3 module assemblies to complete and all work should be complete by Summer 2016.

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
	Recommendation(s) • Since the MAB has a substantial amount of work remaining in addition to the work on Unit 2 CA03, it is recommended that a resource-loaded schedule be developed and some type of plan to predict and measure performance. Since this is not typical construction work, an example might be jobhours per lineal foot of weld. The development of these tools should help keep the work on schedule and within budget. Since the shop is performing so well, a study should be performed to see what other work they can be perform as they complete module work.
CPC2	Observation(s) The Unit 2 auxiliary building CA20 module was set in May 2014, however the fabrication and assembly was incomplete. The outstanding work was substantial and was reported to Bechtel to be as much as 50%. Seventeen months after setting the module, work continues in the field to complete the assembly. The work in the field is substantially more difficult and costly as compared to performing it in the controlled environment of the MAB, which allows easier access using man lifts which cannot be used in the field, better lighting for two shift work, and inside a building so weather is not a factor. Recommendation(s) • A detailed evaluation of the to-go work should be performed so that management understands the cost and schedule impacts before deciding to install something out of sequence. The result of the decision to install the CA20 module has been time consuming and costly.
CPC3	Observation(s) • An observation from the POD meetings is that the details discussed in these meetings results in micromanagement and short term planning of the specific construction activity. This type of detail management may be needed to resolve engineering (since it is in punch list mode), procurement, or quality items affecting the construction work, but for this phase of the construction, the detailed construction planning should be done by the area teams. • It was observed that approximately 30 people attend the daily POD, however less than 15 provide input. The remaining participants are there to answer any question that may come up. • Four days per week, the area supervision team spends significant time to gather information to meet with the PMO personnel to provide status of the day's progress and issues so they can be knowledgeable at the POD. This takes craft supervision out of the field, away from the craftsmen where they are needed. Recommendation(s) • The focus of the POD should be on resolution of issues (i.e., engineering, procurement, and quality) impacting the construction activities. The area construction teams should develop the three week look-ahead schedule and monitor the plan in the area construction meeting, which should not be held more than twice per week. The reason the project of this size is broken down into areas is because it is too big to manage construction from a central group (for example, a PMO). Delegate to the area team the responsibility for cost and schedule. The PMO should provide support to resolve engineering, procurement, and quality issues as needed and integrate all facets of the project.

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
CPC4	Observation(s) The field material requisition process is time consuming, resulting in delays in schedule and impacts to productivity. There are nine (9) people who sign off on field requisitions and if one requires changes, the process stops, the changes are made, and the process starts all over again. Several superintendents have indicated that this process applies to all material including construction aids and construction materials. Recommendation(s) • Look at streamlining the process for construction aids and material. In addition, look at expanding the min/max program to ensure enough material is continuously maintained to adequately support construction. This would cover items such as stock steel (angles, channels, etc.), fasteners (bolts, nuts, washers, etc.), piping material (studs, gaskets, etc.) and conduit fittings and unistrut.
CPC5	Observation(s) A review of the reading room documents suggests that the budgeted unit rates may not have been estimated and resource-loaded to account for differing locations and complexity. As an example, the budgeted unit rate of 35 to 36 jobhours per ton for rebar installation is used for standard as well as complex installations. The turbine pedestal, elevated slabs, and wall rebar installations require higher unit rates than a base mat installation. Craft productivity against the as budgeted unit rates has been difficult to achieve to date. This results in poor morale and an unmotivated effort to measure craft productivity. Recommendation(s) • The project should complete a reforecast based on to date performance, and establish realistic unit rates for the bulk installations. These realistic unit rates times the forecasted quantities will result in better projections of manpower needs by craft needs and craft performance can be monitored. • Adjust the rates to take into account present performance impacts such as: work packaging, skill levels, experience of personnel, and 10 CFR 52 licensing requirements.
CPC6	Observation(s) • The current status of piping deliveries to each unit are as follows: — Unit 2: 82% B31.1 is at site; 56% ASME is at site — Unit 3: 63% B31.1 is at site; 28% ASME is at site • It was stated that 20% to 30% of delivered spools at the site require rework due to changes which include revisions due to valve lengths changes, equipment nozzle relocations, etc. WEC's Engineering Manager explained that the majority of the changes were due to movement of hangers on the piping isometrics, not physical changes to the pipe. Recommendation(s) • The project needs to determine how much rework is required on the delivered pipe spools and get it done prior to delivery to the installation point.
CPC7	Observation(s) Indirect labor and materials are a major cost to the project. Presently there are more crafts working indirect (1,100) than direct (800) work. Normally on a project at this stage, indirect costs should be

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
	about 30% of direct costs. The addition of an Indirects Manager three (3) months ago is a good addition to the team. This manager will provide visibility to indirect charges so management can make the appropriate changes and reduce the costs. Additionally, a review of the construction equipment plan shows a large part of the construction equipment demobilizing next year, which appears to be too early based on progress to date. Recommendation(s) • The project should develop a craft staffing plan to reduce the indirect costs and staffing to a reasonable level. It should be monitored weekly just like direct work. A reforecast should also be performed along with a revised equipment plan.
CPC8	Observation(s) A comparison between CB&I non-manual organizational charts issued 7 months apart revealed significant non-manual turnover. The turnover included several key areas such as the Unit 2 Nuclear Island Construction Manager (this is the fifth manager since the project began), MAB Area Construction Manager, Turbine Building Area Construction Manager, as well as non-manual personnel reporting to area managers. The reported turnover of non-manual is greater than 17%. With such a high turnover rate it will be difficult to build a productive non-manual organization. Recommendation(s) • Perform an evaluation of why the turnover in non-manuals is so high. Areas to investigate would include the demand to work excessive overtime, conflicting management direction, or the micromanagement of personnel. The resolution of some of these potential issues would help reduce the turnover of the non-manual workforce.
CPC9	Observation(s) There were 21 rebar dowels left out of Lift 4 of Unit 2 containment slab placement. Engineering required that the dowels be replaced by core drilling and grouting in the dowel rebar. The resolution of the issue and the completion of the work caused weeks of delays to the containment work and possibly the project. Numerous personnel have cast doubt on whether these dowels really needed to be grouted in; i.e., dowel bars with 90 degree or 180 degree hooks could possibly have been used to obtain the required bar development length without core drilling and grouting. Recommendation(s) • A dedicated team of senior subject matter experts from both WEC and CB&I engineers should be engaged to review these types of situations to ensure that the proposed fix, which will have a significant impact on schedule, is really required. In addition, this team should assist with resolution of critical issues from the time of discovery of the issue to ensure it is resolved with as small an impact to the project as possible.
CPC10	Observation(s) • The project has had difficulty hiring skilled craftsmen, especially rebar ironworkers. When the project reaches peak staffing the need for pipefitters, welders, and electricians will increase substantially. It is estimate that this project will need in excess of 900 pipefitters and 700 electricians. • Bechtel visited the onsite training facility and were impressed with the capabilities. The Consortium had just trained 13 rebar ironworkers which was immediately helpful to the project and

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
	this type of "immediately needed training" needs to be expanded. • A project-specific labor survey had not been recently performed. Recommendation(s) • In addition to onsite training, CB&I should consider establishing a training school off site (possibly at local vocational schools) to train pipefitters, electricians, and welders to insure they can fill their needs in a timely manner. • There are 6 onsite classrooms available which should be used full time to develop those crafts that are presently or will be in short supply. • A project-specific labor survey should be performed.
CPC11	Observation(s) Aging of the construction workforce is impacting productivity. Recommendation(s) • Develop mentoring and training plan to promote junior craft and field engineering personnel with periodic evaluations and feedback sessions. • Create and staff shadow positions for senior level positions within the Consortium intent on developing new talent that is focused on project completion.
CPC12	Observation(s) The concrete being used is self-consolidating and does not need vibrating. However, in a number of areas, mostly where there is dense rebar, voids in the concrete were evident. Recommendation(s) • In areas of dense rebar, additional consolidation such as standard concrete vibrating or form vibrating should be used to ensure complete consolidation of the concrete.
CPC13	Observation(s) • Presently, some parts of the project are working 58 hours (5-10s and 1-8 hours). Studies by the Business Roundtable, Construction Industry Institute, and Trade Unions have been done to assess the impact of working extended overtime. They have shown that after eight (8) weeks, the productivity drops by approximately 40%, which means that you would be getting 40 hours of work for 58 hours pay. Extended overtime also has an effect on absenteeism, accidents, physical and mental fatigue, morale, attitude, turnover and supervision decisions. The schedule also suffers, which adds more pressure to work overtime. • In discussions with CB&I Industrial Relations, it was stated that when the recruiters hire craft personnel, they are told the project is on 4-10s and 8. A general feeling is that the project would maintain the work force if the 6 day weeks were stopped. • The craft turnover rate is 20%. CB&I is expending a lot of money to hire and orient craftsmen. Recommendation(s) • The work week should be reduced to no more than 48 hours (4-10s and 1-8 hours). With the monies saved not working as much overtime, consideration should be given to a craft incentive plan that rewards staying on the project until given a reduction in force, and/or productive and safety incentive. • To reduce the turnover, CB&I should consider a craft incentive of $1/hr which would only be

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
	paid when a reduction in force occurs.
CPC14	Observation(s) There are occasions where the construction team is too optimistic when scheduling work. Recommendation(s) • Work activities should be planned based on a realistic evaluation of the work, rather than optimistic projections due to schedule pressure from management. This way, craftsmen will be working productively. The project should consider a rule that the placement must be signed-off, except for final clean up, the day before the placement
CPC15	Observation(s) Although the construction team is being pushed hard to maintain schedule, the project schedule continues to slip for a variety of reasons, including design changes and clarifications. As a consequence of the focus on schedule, the cost does not receive the attention it should. The craftsmen do not focus on productivity as they should due to the schedule changes over which they have only partial control. The outcome of this will be an extended schedule and a cost overrun. Recommendation(s) • Maintain the schedule focus, but not at the expense of project cost. When engineering issues arise, adjust the schedule accordingly, so the craftsmen still feel they have some control and responsibility for working the schedule within budget.
CPC16	Observation(s) During walkdowns of the Unit 2 turbine building and the Unit 3 nuclear island, it was noticed that there were numerous work faces available, but no work was underway. The Unit 3 containment had only approximately 100 craft working. When this was questioned, both superintendents stated that craft personnel had been moved to the Unit 2 nuclear island as it was more important. Recommendation(s) • Staff up to allow working of all available work areas. Leave craftsmen assigned to one area so they feel they are part of an area team. It may be appropriate to combine the Unit 2 and Unit 3 containment to better use non-manuals and make some personnel available to fill other project needs. This would allow better incorporation of lessons learned by both non-manuals and craftsmen in Unit 2 to improve Unit 3 performance and schedule.
CPC17	Observation(s) • The superintendent provided drawings of the raceway and hangers in the containment which showed congested areas. From looking at the drawings it is evident that there will be numerous interferences. Additionally, the electrical hangers are much more complex than normal electrical hangers. • In the containment, hangers are located by plant latitude and longitude. Locating these will require a survey crew rather than allowing the craftsmen to do it. Recommendation(s) • An interference review should be performed and any interference found should be resolved prior to start of installation. Some estimates should be performed to determine whether it is cheaper to install the hanger as designed or redesign the hanger. Once a decision is made, a

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
	reforecast should be performed to determine what the real costs would be. • Hanger locations need to be located on the drawing using reference lines in the containment.
CPC18	Observation(s) Based on discussions with supervision and field engineering and attending the PMO meetings, it is apparent that there are numerous design changes and design clarifications that affect the work resulting in negative impacts to the schedule of the work. The majority of these are in the civil discipline. One would expect similar issues in piping mechanical and electrical. Recommendation(s) • Ensure that the design organization recognizes the importance of design changes and clarifications and is staffed to address them immediately. The negative impacts to the project will not decrease as long as changes continue and clarifications are slow to come from engineering and will continue throughout the project unless a change is made.
CPC19	Observation(s) The present staffing curves for manual manpower are classic bell shaped curves. Based on Bechtel's experience, the manual manpower curve will increase towards the latter part of the project and then drop off sharply at the end of the project. In addition, there are no crafts shown on the chart nine (9) months prior to commercial operation to close out punch list items. Recommendation(s) • Re-evaluate the staffing levels based on historical data and ensure there are crafts budgeted for punchlist completion.
CPC20	Observation(s) Installation tolerances are provided for all commodities and may not be exceeded without prior engineering approval. CB&I construction has attempted to relax the requirements and documented their requests in the civil generic guidance document. There are numerous situations where the commodity cannot be installed because of design interferences. As each situation arises, progress is affected while engineering evaluates the situation. The Strategic Planning Group is trying to identify these interferences, but they are not able to identify all of them. Recommendation(s) • Assemble a team of subject matter experts who can meet with field engineering to identify those areas where tolerance increases would help solve installation and interference problems. Examples would include increasing rebar spacing tolerances, increasing pipe location tolerances, etc.
CPC21	Observation(s) The project team has a robust safety program which has achieved some impressive results. The safety package handed out at the weekly safety meeting contained a one page tailgate topic for each day of the week. Some of the tailgate write-ups are overly detailed and contain a substantial amount of information, which might be hard to understand and retain. Recommendation(s) • Keep up the good work! The safety department might consider simplifying the tailgate write-up so it could be easier to understand and retain. (For example, the September 25, 2015 tailgate

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
	topic on chemical labeling was perhaps too complex.) • At the daily morning safety briefing, each craftsman is required to sign the morning bulletin. This probably takes 15 minutes for the crew to sign the bulletin which is 15 minutes the craft is not at the work face. The need for signatures should be re-evaluated.
CPC22	Observation(s) • The current work package procedure requires the craft foreman (or his designee) to check out the work package each morning and return it to document control each night. If changes have occurred in the last 24 hours it is on hold until field engineering updates it. The work packages must be at the work face during work activities. Some work packages are hundreds of pages long and they contain all related drawings, drawing changes and specifications. A significant amount of time is lost each day implementing the work package process. • Some work packages contain three volumes, some of them over three inches think. The foreman only needs a small amount of this paperwork to perform his daily tasks. Recommendation(s) • Assign a team to review and streamline the work package process. One change might be having the responsible field engineer hold the work package and only issue the relevant drawings (and changes) and inspection, hold points, and signoff sheets to the foreman. • At a minimum, incorporate the design changes into the construction drawings before the craft start work. (It is time consuming for the foreman to refer to multiply design change documents when trying to execute the work). Remove the specifications and standard details from the packages given the foreman, they can be referenced and copies kept in the field stick file trailers. The work packages should only include what is needed by the foreman for their work.
CPC23	Observation(s) Normally, the bulk commodity installation curves are somewhat parallel with the civil work in advance of the piping which is in advance of the electrical work. On the V.C. Summer project, the curves do not parallel each other with some electrical work crossing piping. The time between commodity installations does not appear sufficient to allow installation of bulks in an efficient manner. Recommendation(s) • Adjust the schedule for the bulk installation of commodities to allow enough time between work activities to achieve an efficient and cost effective installation program.
CPC24	Observation(s) • The monthly progress report shows construction progress advancing approximately 0.5% per month with a total to date (August 2015) of 21% complete. In order for the plant to complete on schedule, monthly construction progress must increase to close to 3%. There are several work faces without craftsmen, (examples: Unit 2 turbine building elevated slabs; the Unit 3 containment only had 100 men working, and no work in the Unit 3 turbine building.) • It takes approximately one hour before the craftsmen get to their workplace. At both of the coffee breaks and lunch time, the craftsmen leave the work area resulting in unproductive time leaving and returning to work.

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
	Recommendation(s) • The project needs to staff up to work all available work faces. • Assign a senior construction person to evaluate methods to have the craftsmen spend more time at the workface (One example: move the tool boxes into the building near the work area.) • Have coffee breaks and lunch in the work areas.
CPC25	Observation(s) The Consortium's Integrated Project Schedule has 50 mandatory constraints--20 associated with Unit 2, 24 associated with Unit 3, and six site-specific. • A majority of the mandatory constraints affect fabrication of shield building panels that are forecast for later deliveries from the fabricator, the latest being for Unit 2 149'-6" transition panels currently forecast to be complete 9 months later than the constrained date. The Consortium stated during the September 9, 2015 presentation that a mitigation plan is in process for the shield building panels. • There is a constraint on the Unit 2 auxiliary building R251 module that is currently forecasted to be complete 5 months later than the constrained date. • There is a constraint on the Unit 3 CA01 module ready to lift that is currently forecasted to complete 4 months later than the constrained date. • There is a constraint on the Unit 3 CA20 module ready to lift that is currently forecasted to complete 4 months later than the constrained date. Recommendation(s) • Remove mandatory constraints, and allow the schedule to move based on the logic. Prioritize development of mitigation/recovery plans based on their potential impact to the schedule. Only incorporate mitigation plan recovery into the schedule after it has been fully developed and approved by all parties.
CPC26	Observation(s) The baseline forecast was developed based on a performance factor of 1.15. Recent (last 6 months) performance has been greater than 2.0 on Unit 2, and greater than 1.5 on Unit 3, primarily driven by civil building construction impacts. Recommendation(s) • Update the forecast based on recent performance. Reassess manpower needs based on updated forecast. • Implement a small sample of piping and electrical work packages well ahead of bulk installation period to assess potential impacts early. • Plan to ramp-up slowly, gradually, to achieve an acceptable productivity level, train leads, and identify challenges and impediments prior to ramping up to full bulk installation mode.
CPC27	Observation(s) The Owners' oversight organization does not have a proper Project Controls staff. Recommendation(s) • Hire an experienced project controls manager, lead planner, and lead cost engineer to perform analysis of the Consortium schedule and cost forecasts. • A separate set of tracking tools should be created by the Owner to provide verification of

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
	Consortium reporting. • Special attention needs to be made on the cost reimbursable portions of the scope. This newly formed Project Controls group would provide recommendations and identify areas requiring additional investigations.
CPC28	Observation(s) Consortium reports are provided in either a summary form or in an integrated manner making validation difficult. Recommendation(s) • Where contractually possible, the Owners should request the data that creates the reports not just the reports. The recommended Project Controls team would then analyze the data rather than just reviewing the report.
CPC29	Observation(s) The Consortium has narrowed focus into individual windows with a total horizon of around 9 months. The project reporting has followed suit and a majority of the reports provided focus upon this short time horizon. The reports to the Owners need to continue to be overall project focused. Recommendation(s) • Request all reports provided by the Consortium for the monthly meetings contain the overall view regardless of topic. Breakouts are acceptable and sometimes needed, but overall focus must remain on the overall project performance.
CPC30	Observation(s) Not all reports and or graphical representations provided within reports include the baseline and/or the Consortium's current forecast. Recommendation(s) • Request all reports provided to the Owners include both baseline information and a current forecast if different than the baseline. If the current forecast is later than the baseline, the Consortium should provide a recovery forecast plan. If cost is being discussed and the cost forecast exceeds the baseline, an estimate at completion should be required.
CPC31	Observation(s) Bechtel was told that the contract contains a portion of fixed price and cost reimbursable terms. The charging practice, if not tracked closely, could allow for improper cross charging between accounts. Recommendation(s) • Request staffing plans by position which account for the total project baseline budget for the tracking of jobhours. For the tracking of material type budgets, such as equipment or small tools, a baseline monthly usage plan should also be submitted for baseline tracking purposes. This document would serve as the basis for future negotiations and would provide enough detail for scope increase discussions and also validation of current actual charges.
CPC32	Observation(s) Schedule contingency has not been included within the integrated schedule.

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
	Recommendation(s) • Analyze the schedule to identify activities within the critical and near critical paths that contain potential float. At the time of rebaselining the schedule, a schedule contingency analysis should be run and the desired probability of outcome should be agreed on.
CPC33	Observation(s) In reviewing the bulk piping curves, it was identified that the underground and aboveground commodities were included within the same chart. Tracking these together can be misleading especially when validating the sustained rates to ensure an achievable plan. Recommendation(s) • Separate the curves and track all underground quantities separate from aboveground quantities. Also, after creating separated curves, compare the current installation plan to historicals to validate their viability.
CPC34	Observation(s) While reviewing the bulk curves, it was identified that the bulk curves were not developed through the use of standard "S" shape curves. The "S" curves were altered to allow for additional time between the 10% and 90% completion windows to lower the sustained rates. This artificial increase in the sustained rate window reduces the sustained rate for comparison purposes but does not alter the real installation pace required to meet the plan. Recommendation(s) • Only use a standard "S" shaped work-off curve when evaluating the schedule duration viability.
CPC35	Observation(s) Bulk quantity installation curves reflect an overly aggressive plan when compared to Bechtel historical experience of peak sustained installation rates. Also, the separation of each commodity within the "family of curves" is not reflective of Bechtel historical experience. An example of this is the distance between the raceway and cable percent complete curves. The cable installation percent complete follows closely to the raceway installation percent complete. Historically, the more achievable plan reflects that a substantial portion of the installation of tray and conduit is complete prior to the commencement of cable pulling. This separation allows for pulls from point to point without having to coil at each end. Having to coil the cable rather than pulling to its final location creates additional hours due to double handling. Recommendation(s) • Create a new more achievable baseline Level 3 schedule. During development of the schedule, ensure appropriate time is allocated for bulk installation windows. • Update the schedule forecast based on median range of achievable peak sustained rate. • Review quantities by system, and align to the schedule and start-up system waterfall. Prioritize bulks by system turnover demands. Balance this priority with area releases, and methods that would allow the highest productivity to be achieved. Compare system driven quantity curve against peak sustained rate forecast, and adjust accordingly. • Plan work packages around the most productive methods of bulk installation (e.g., cable trees), with consideration for ability to support system turnovers.

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
CPC36	Observation(s) • During the review and analysis of the quantities provided by the Consortium, it was identified that the total quantity of aboveground conduit appears to be high compared to Bechtel historicals. • Inversely, the total quantity for cable appears to be low. These quantities were also reviewed from a ratio perspective and result in an overall ratio unlike any of Bechtel's past projects. Recommendation(s) • Review the electrical quantities in the annex building and turbine building and update as needed. Revise the Level 2 and 3 schedules and also the bulk curves to align with the account for the new quantities.
CPC37	Observation(s) • The consortium project schedule is large and complex, forcing daily maintenance and status updates. Varying levels of the schedule are comingled in the same projects, and are loaded with varying degrees of resource data, resulting in duplication • The Level 1 schedule (as presented in the monthly project review meeting package) effectively highlights the critical path and major project activities on a single page. However, dates are only included for certain activities and a timescale is not provided, therefore target and forecast dates for other major activities are not clear. The schedule also appears to start in January 2015, showing no status of actual work completed prior to that date. • The Level 2 schedule is made up of "WBS summary" (work breakdown structure) type activities which are essentially hammock activities for all detailed activities within that WBS. This schedule provides a summary by unit, building, elevation, and commodity, and is fully resource loaded with jobhours through project completion. The Level 2 schedule appears to have many activities working in parallel, which isn't necessarily the case. When viewed at a lower level of detail, the Level 2 hammock (summary) activities capture all activities from fabrication through punch list and touch-up activities. In many cases, fabrication begins several months or more prior to installation, and there are also large gaps between bulk installation and final completion activities within a WBS (work breakdown structure). This approach skews the Level 2 activities into much longer durations than when the bulk of the work is actually planned to be performed. Furthermore, as the Level 2 schedule is fully resource loaded, this approach is spreading those resources over a longer period of time, reducing the resulting peak manpower requirements. This can be problematic if the Level 2 schedule is the primary tool being utilized to determine manpower requirements. • The Level 3 schedule is the detailed working level schedule for the project. Development of this schedule is ongoing, and is currently being reviewed at 6 to 9 month durations beyond the data date. Due to the level of detail and number of activities in this schedule, this schedule is considered to be a Level 5 implementation schedule. Resources are being loaded in this schedule as well as some quantities, but do not appear to be complete enough to be used for forecasting purposes. The Consortium's project controls group is performing daily reviews of this schedule due to its large size and complexity, and the volume of changes being input on a day-to-day basis. The team has established a good process for managing the existing schedule, but daily updating and reviews are excessive for this size and scope of project. Recommendation(s)

Table 5-2. Construction and Project Controls Observations and Recommendations	
No.	**Description**
	• Adjust the Level 1 schedule to include a time-scaled baseline and target and forecast dates for all identified activities. Expand the start of the window schedule to show major project status since project inception. • Create a Level 3 control schedule with no more than 5,000 activities per unit. The Level 2 schedule can be used at a starting point, but would need to be converted to "task" activities as opposed to "hammock activities". The Level 3 schedule should be at a sufficient level of detail to identify all critical interfaces between each phase of the project. The recommended structure is to identify construction activities by unit, building, elevation, area, and commodity. A custom data field should be added to identify systems associated with each activity, to ensure proper tie in from construction to startup. This schedule should be resource loaded with key quantities and jobhours and maintained/aligned to the current forecast for the project. Weekly meeting and management reviews should use this Level 3 schedule as opposed to lower level schedules. • Develop more detailed Level 5 implementation schedules as needed to manage near term commitments for critical areas. These can be in Excel rather than Primavera, and in addition to time-scaled format, can be in the form of a bingo-sheet, checklist, or other method to track status. Primavera is currently over-used for this level of the schedule, demanding more maintenance, update, meetings, etc., that strain project resources.

Figure 5-1. V.C. Summer Units 2 & 3 Project Assessment
Summary Schedule

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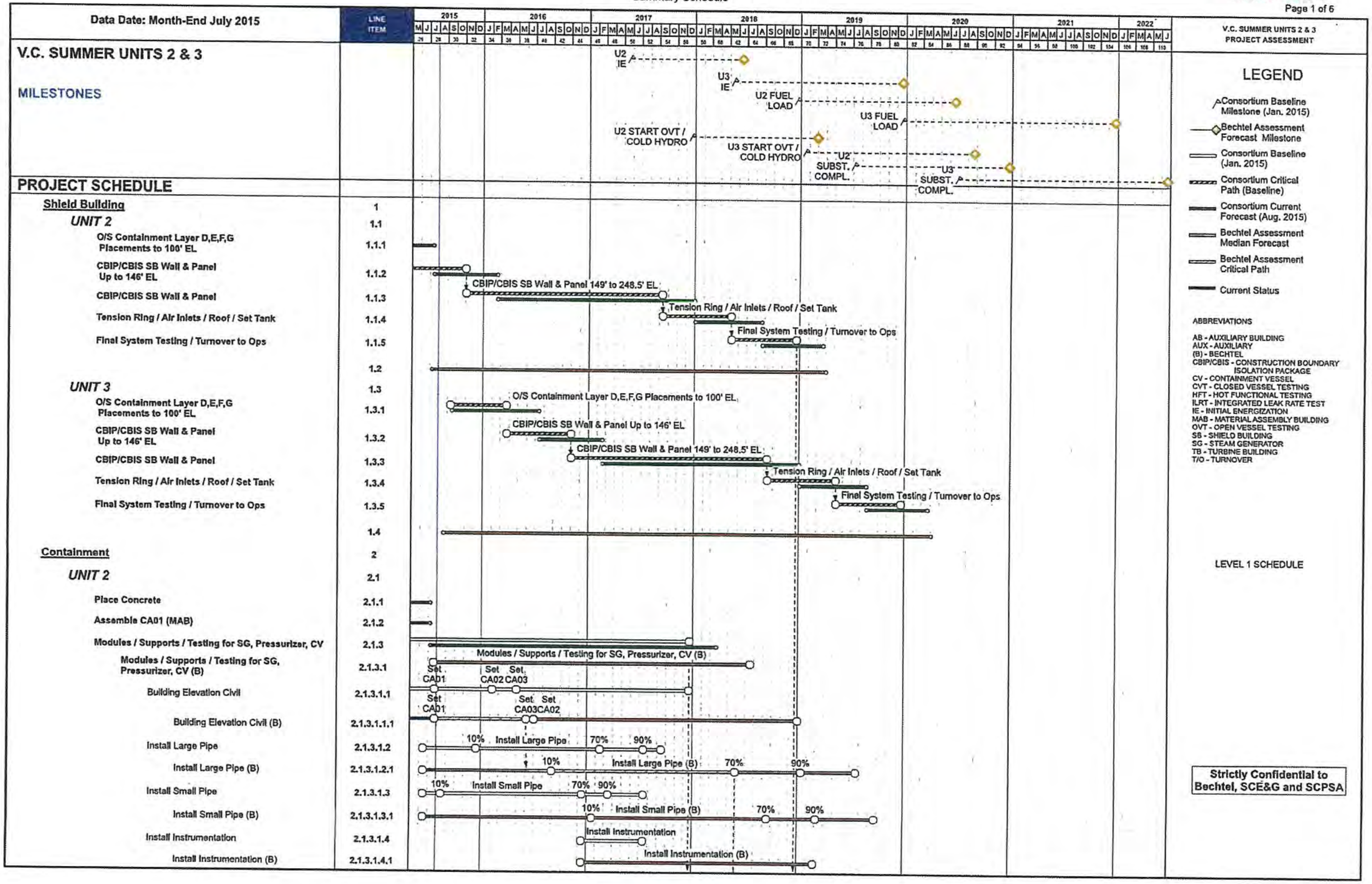

Figure 5-1. V.C. Summer Units 2 & 3 Project Assessment
Summary Schedule

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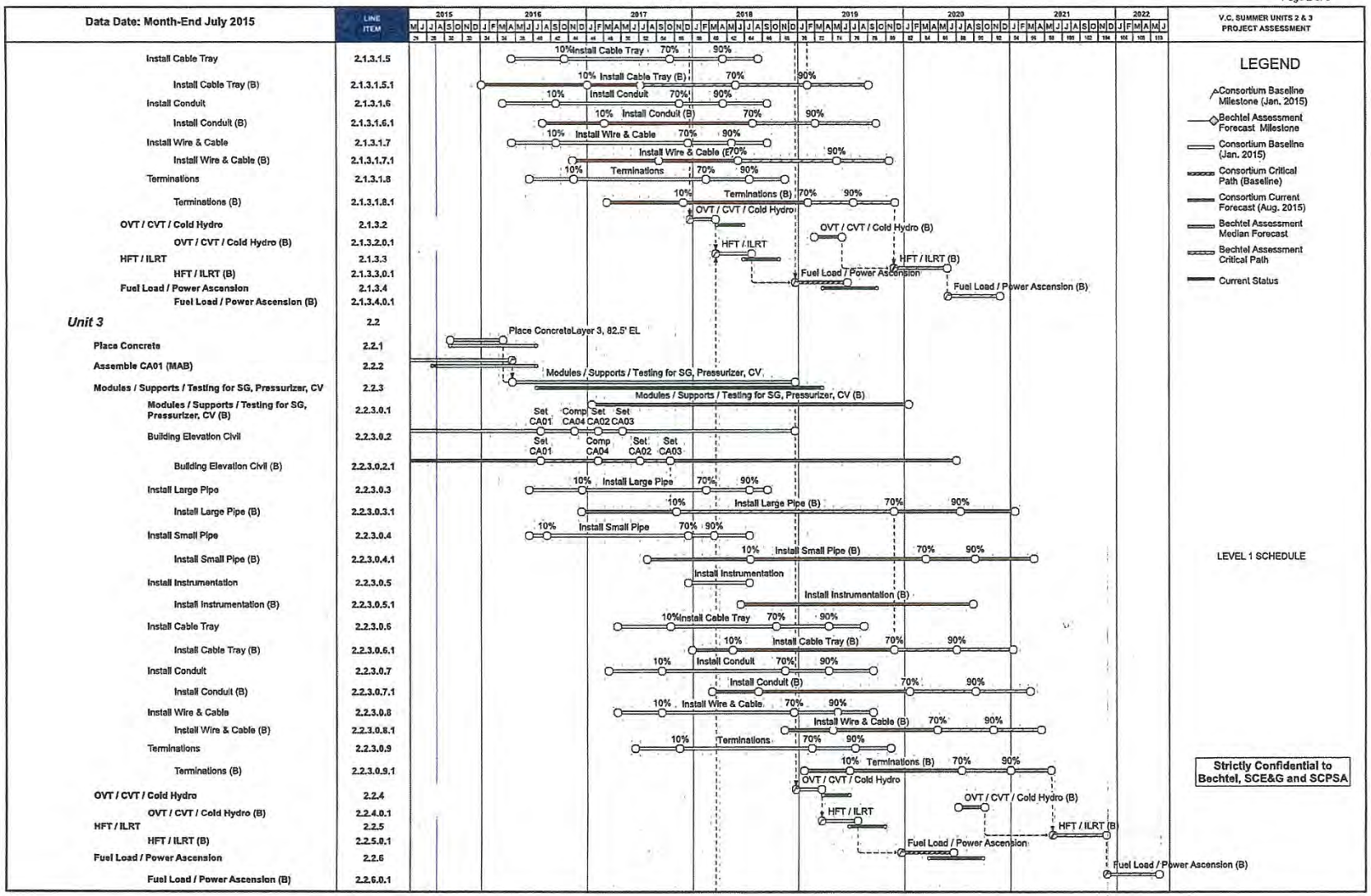

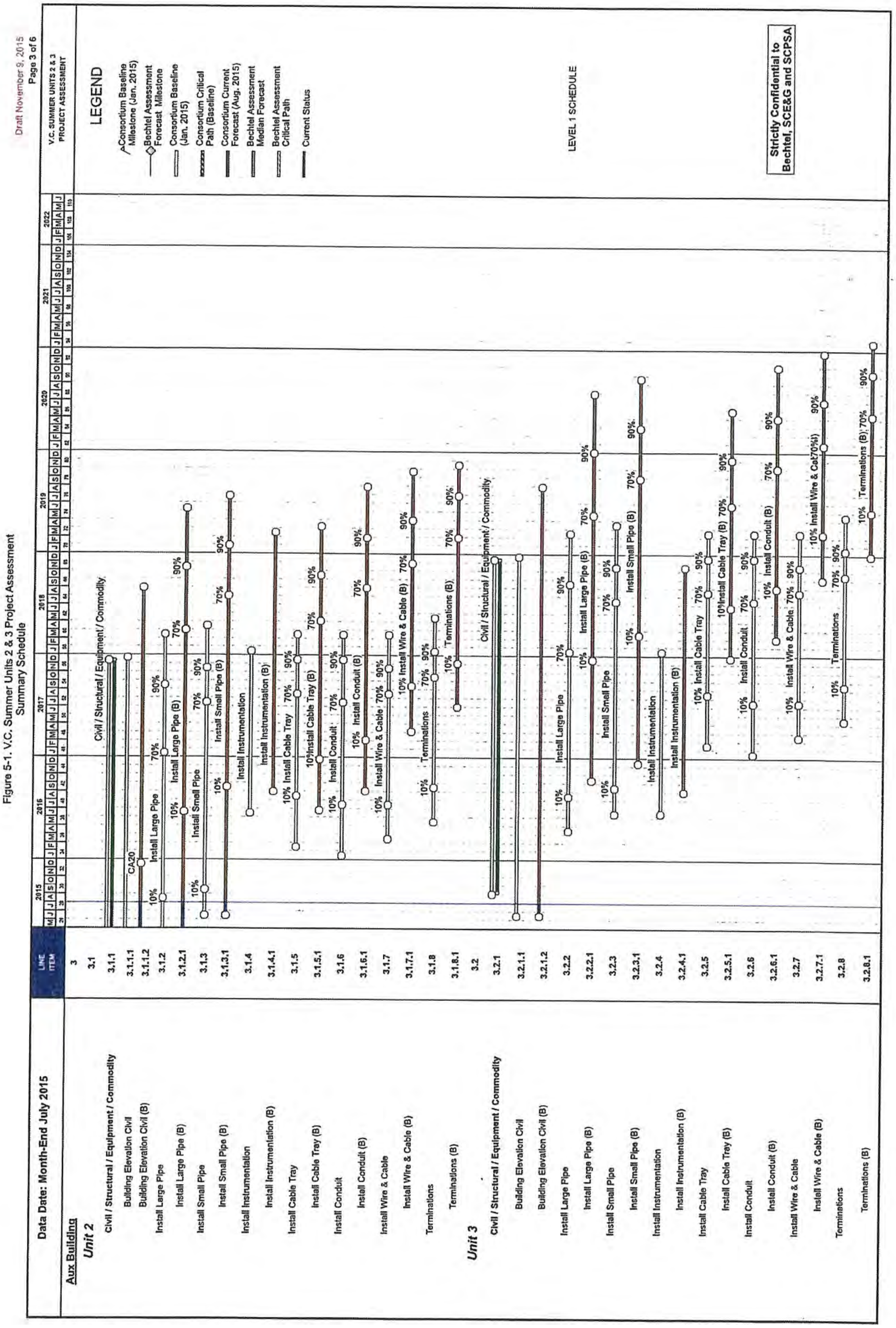
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Figure 5-1. V.C. Summer Units 2 & 3 Project Assessment Summary Schedule
Data Date: Month-End July 2015
V.C. SUMMER UNITS 2 & 3 PROJECT ASSESSMENT
LEGEND
Consortium Baseline Milestone (Jan. 2015)
Bechtel Assessment Forecast Milestone
Consortium Baseline (Jan. 2015)
Consortium Critical Path (Baseline)
Consortium Current Forecast (Aug. 2015)
Bechtel Assessment Median Forecast
Bechtel Assessment Critical Path
Current Status
LEVEL 1 SCHEDULE
Strictly Confidential to Bechtel, SCE&G and SCPSA
Aux Building
Unit 2
Civil / Structural / Equipment / Commodity
Building Elevation Civil
Building Elevation Civil (B)
Install Large Pipe
Install Large Pipe (B)
Install Small Pipe
Install Small Pipe (B)
Install Instrumentation
Install Instrumentation (B)
Install Cable Tray
Install Cable Tray (B)
Install Conduit
Install Conduit (B)
Install Wire & Cable
Install Wire & Cable (B)
Terminations
Terminations (B)
Unit 3

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Figure 5-1. V.C. Summer Units 2 & 3 Project Assessment
Summary Schedule

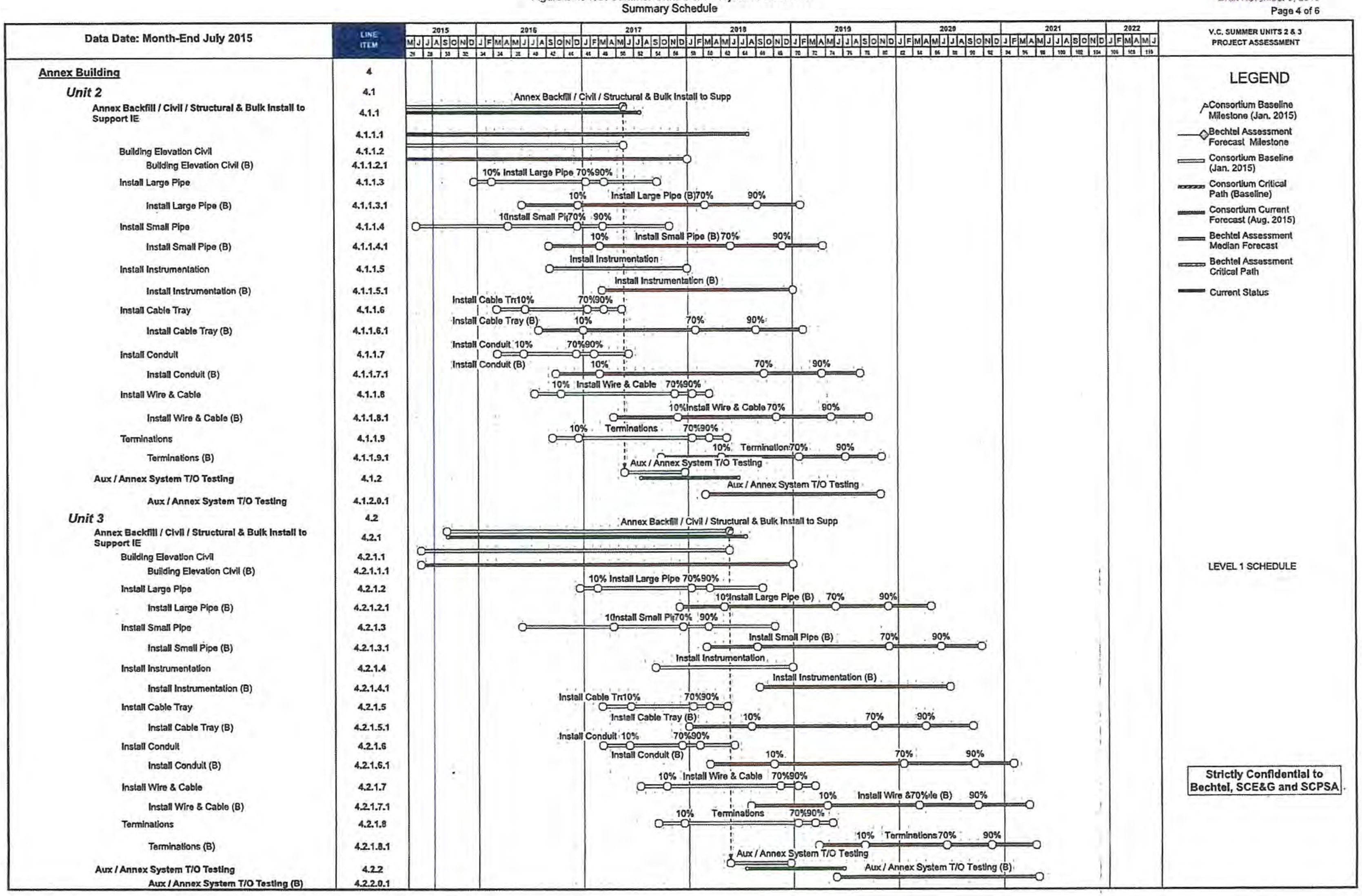
Data Date: Month-End July 2015
LINE ITEM
2015
2016
2017
2018
2019
2020
2021
2022
V.C. SUMMER UNITS 2 & 3
PROJECT ASSESSMENT
Annex Building 4
Unit 2 4.1
Annex Backfill / Civil / Structural & Bulk Install to Support IE 4.1.1
4.1.1.1
Building Elevation Civil 4.1.1.2
Building Elevation Civil (B) 4.1.1.2.1
Install Large Pipe 4.1.1.3
Install Large Pipe (B) 4.1.1.3.1
Install Small Pipe 4.1.1.4
Install Small Pipe (B) 4.1.1.4.1
Install Instrumentation 4.1.1.5
Install Instrumentation (B) 4.1.1.5.1
Install Cable Tray 4.1.1.6
Install Cable Tray (B) 4.1.1.6.1
Install Conduit 4.1.1.7
Install Conduit (B) 4.1.1.7.1
Install Wire & Cable 4.1.1.8
Install Wire & Cable (B) 4.1.1.8.1
Terminations 4.1.1.9
Terminations (B) 4.1.1.9.1
Aux / Annex System T/O Testing 4.1.2
Aux / Annex System T/O Testing 4.1.2.0.1
Unit 3 4.2
Annex Backfill / Civil / Structural & Bulk Install to Support IE 4.2.1
Building Elevation Civil 4.2.1.1
Building Elevation Civil (B) 4.2.1.1.1
Install Large Pipe 4.2.1.2
Install Large Pipe (B) 4.2.1.2.1
Install Small Pipe 4.2.1.3
Install Small Pipe (B) 4.2.1.3.1
Install Instrumentation 4.2.1.4
Install Instrumentation (B) 4.2.1.4.1
Install Cable Tray 4.2.1.5
Install Cable Tray (B) 4.2.1.5.1
Install Conduit 4.2.1.6
Install Conduit (B) 4.2.1.6.1
Install Wire & Cable 4.2.1.7
Install Wire & Cable (B) 4.2.1.7.1
Terminations 4.2.1.8
Terminations (B) 4.2.1.8.1
Aux / Annex System T/O Testing 4.2.2
Aux / Annex System T/O Testing (B) 4.2.2.0.1
Annex Backfill / Civil / Structural & Bulk Install to Supp
10% Install Large Pipe 70%90%
10% Install Large Pipe (B) 70% 90%
10Install Small Pi70% 90%
10% Install Small Pipe (B) 70% 90%
Install Instrumentation
Install Instrumentation (B)
Install Cable Tr10% 70%90%
Install Cable Tray (B) 10% 70% 90%
Install Conduit 10% 70%90%
Install Conduit (B) 10% 70% 90%
10% Install Wire & Cable 70%90%
10%Install Wire & Cable 70% 90%
10% Terminations 70%90%
10% Termination70% 90%
Aux / Annex System T/O Testing
Aux / Annex System T/O Testing
10Install Large Pipe (B) 70% 90%
10Install Small Pi70% 90%
Install Small Pipe (B) 70% 90%
Install Wire &70%le (B) 90%
10% Terminations 70%90%
10% Terminations70% 90%
Aux / Annex System T/O Testing (B)
LEGEND
Consortium Baseline Milestone (Jan. 2015)
Bechtel Assessment Forecast Milestone
Consortium Baseline (Jan. 2015)
Consortium Critical Path (Baseline)
Consortium Current Forecast (Aug. 2015)
Bechtel Assessment Median Forecast
Bechtel Assessment Critical Path
Current Status
LEVEL 1 SCHEDULE
Strictly Confidential to Bechtel, SCE&G and SCPSA

Figure 5-1. V.C. Summer Units 2 & 3 Project Assessment Summary Schedule

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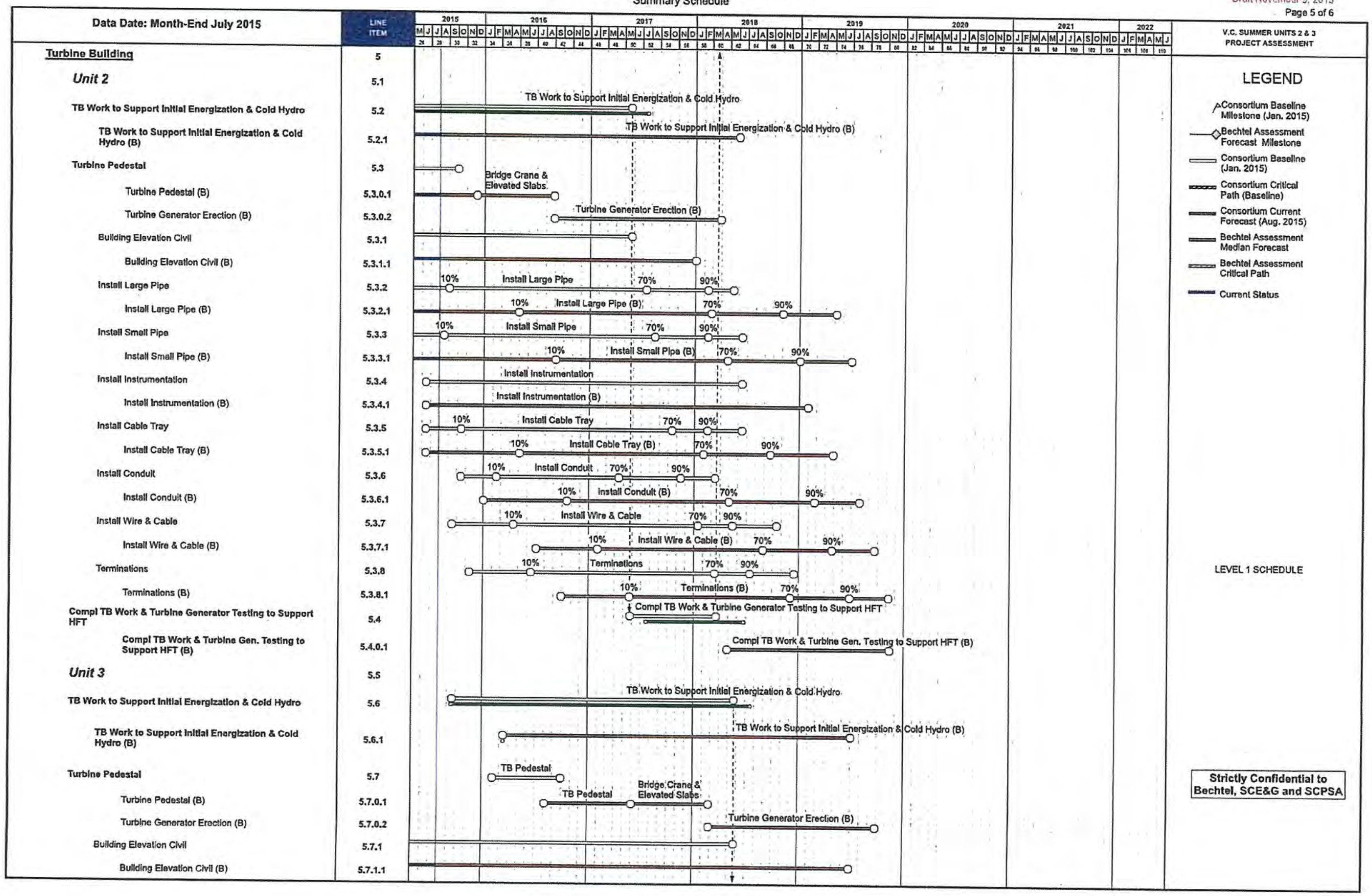
Data Date: Month-End July 2015
LINE ITEM
V.C. SUMMER UNITS 2 & 3 PROJECT ASSESSMENT
Turbine Building 5
Unit 2 5.1
TB Work to Support Initial Energization & Cold Hydro 5.2
TB Work to Support Initial Energization & Cold Hydro (B) 5.2.1
Turbine Pedestal 5.3
Turbine Pedestal (B) 5.3.0.1
Turbine Generator Erection (B) 5.3.0.2
Building Elevation Civil 5.3.1
Building Elevation Civil (B) 5.3.1.1
Install Large Pipe 5.3.2
Install Large Pipe (B) 5.3.2.1
Install Small Pipe 5.3.3
Install Small Pipe (B) 5.3.3.1
Install Instrumentation 5.3.4
Install Instrumentation (B) 5.3.4.1
Install Cable Tray 5.3.5
Install Cable Tray (B) 5.3.5.1
Install Conduit 5.3.6
Install Conduit (B) 5.3.6.1
Install Wire & Cable 5.3.7
Install Wire & Cable (B) 5.3.7.1
Terminations 5.3.8
Terminations (B) 5.3.8.1
Compl TB Work & Turbine Generator Testing to Support HFT 5.4
Compl TB Work & Turbine Gen. Testing to Support HFT (B) 5.4.0.1
Unit 3 5.5
TB Work to Support Initial Energization & Cold Hydro 5.6
TB Work to Support Initial Energization & Cold Hydro (B) 5.6.1
Turbine Pedestal 5.7
Turbine Pedestal (B) 5.7.0.1
Turbine Generator Erection (B) 5.7.0.2
Building Elevation Civil 5.7.1
Building Elevation Civil (B) 5.7.1.1
2015 2016 2017 2018 2019 2020 2021 2022
Bridge Crane & Elevated Slabs
TB Pedestal
10%
70%
90%
LEGEND
Consortium Baseline Milestone (Jan. 2015)
Bechtel Assessment Forecast Milestone
Consortium Baseline (Jan. 2015)
Consortium Critical Path (Baseline)
Consortium Current Forecast (Aug. 2015)
Bechtel Assessment Median Forecast
Bechtel Assessment Critical Path
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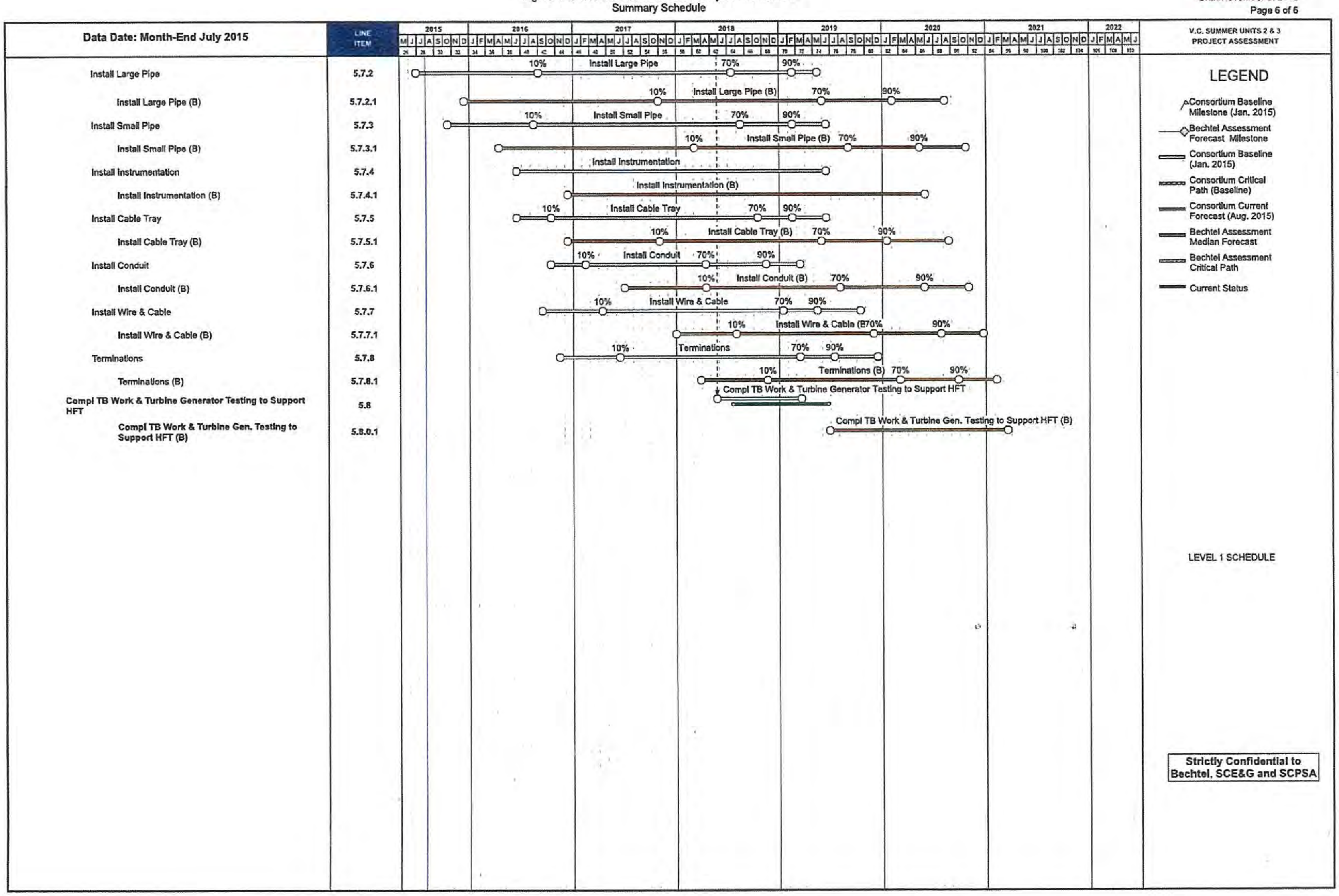
Figure 5-1. V.C. Summer Units 2 & 3 Project Assessment
Summary Schedule


Data Date: Month-End July 2015
LINE ITEM
2015
2016
2017
2018
2019
2020
2021
2022
V.C. SUMMER UNITS 2 & 3 PROJECT ASSESSMENT
Install Large Pipe
5.7.2
Install Large Pipe (B)
5.7.2.1
Install Small Pipe
5.7.3
Install Small Pipe (B)
5.7.3.1
Install Instrumentation
5.7.4
Install Instrumentation (B)
5.7.4.1
Install Cable Tray
5.7.5
Install Cable Tray (B)
5.7.5.1
Install Conduit
5.7.6
Install Conduit (B)
5.7.6.1
Install Wire & Cable
5.7.7
Install Wire & Cable (B)
5.7.7.1
Terminations
5.7.8
Terminations (B)
5.7.8.1
Compl TB Work & Turbine Generator Testing to Support HFT
5.8
Compl TB Work & Turbine Gen. Testing to Support HFT (B)
5.8.0.1
10%
70%
90%
LEGEND
Consortium Baseline Milestone (Jan. 2015)
Bechtel Assessment Forecast Milestone
Consortium Baseline (Jan. 2015)
Consortium Critical Path (Baseline)
Consortium Current Forecast (Aug. 2015)
Bechtel Assessment Median Forecast
Bechtel Assessment Critical Path
Current Status
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